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REPORT ON THE

TRIANGULATION

OF

GREATER NEW YORK

BY THE CO-OPERATION OF THE

CITY OF NEW YORK

AND THE

UNITED STATES COAST AND GEODETIC SURVEY

EXECUTED 1903 TO 1908

REPORT ON THE

TRIANGULATION

OF

GREATER NEW YORK

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EXECUTED 1903 TO 1908

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BOARD OF ESTIMATE AND APPORTIONMENT, CITY OF NEW YORK,
OFFICE OF THE CHIEF ENGINEER,
277 BROADWAY,

January 25, 1909.

Hon. GEORGE B. MCCLELLAN, *Mayor,*
Chairman of the Board of Estimate and Apportionment:

SIR—I beg to submit herewith the final report of the Triangulation of The City of New York. This work has, in accordance with the provisions of Section 139 of the Greater New York Charter, as amended by Chapter 406 of the Laws of 1903, been carried out pursuant to an agreement with the Superintendent of the United States Coast and Geodetic Survey, authorized by resolutions adopted by the Board of Estimate and Apportionment on May 8, 1903, and has been under the immediate supervision of Mr. A. T. Mosman, Assistant, United States Coast and Geodetic Survey, who was detailed to this work by the Superintendent.

The reports of Mr. Mosman and of Mr. John F. Hayford, Chief of the Computing Division, made to the Superintendent and by him transmitted to me, describe in detail the methods followed by them in the field work and in the computations.

The arrangement under which this work has been carried out has proven most satisfactory and economical to The City of New York. Officers of the Survey have placed at the disposal of the City, free of charge, a number of their instruments, and every effort has been made by them to insure the high standard of work which has been attained, and the selection of Mr. Mosman, whose experience in the Coast Survey has been long and varied, was most advantageous for The City of New York.

The work which has been accomplished will be of very great benefit not only to that portion of The City for which a plan has not yet been prepared, but to those parts already mapped and to those Departments which have occasion to make precise surveys. I feel safe in saying that no survey of this kind including a large urban area has ever been attempted, and this report will therefore be of special value to all who are engaged in work of this character.

There are a few small bills still outstanding, but the total cost of the work to The City of New York will be approximately $73,000. This includes salaries, office rent, instruments, land purchased for one signal and a number of observing towers and signals, but does not include such of the towers and signals as were erected by the different Borough Presidents.

Respectfully,

NELSON P. LEWIS,
Chief Engineer.

DEPARTMENT OF COMMERCE AND LABOR,
U. S. COAST AND GEODETIC SURVEY,
WASHINGTON, D. C.,
January 12, 1909.

MR. NELSON P. LEWIS,
Chief Engineer, Board of Estimate and Apportionment,
277 Broadway, New York, N. Y.:

SIR—I take pleasure in transmitting herewith a report upon the field work of the triangulation of Greater New York and a report upon the computation of this triangulation. The first has been prepared by Mr. A. T. Mosman, Assistant, Coast and Geodetic Survey, under whose direction the field work was done, and the second has been prepared by Mr. John F. Hayford, Chief of the Computing Division, of the Coast and Geodetic Survey, under whose direction the computations have been made, as specified in the agreement of co-operation between the Coast and Geodetic Survey and the City of New York.

These two reports together constitute a complete report upon the triangulation of Greater New York.

Respectfully,

O. H. TITTMAN,
Superintendent.

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Brooklyn, New York, November 10, 1908.

Mr. O. H. Tittmann, *Superintendent, Coast and Geodetic Survey,*
Washington, D. C.:

Sir—I have the honor to submit the following report on the field work of the triangulation of Greater New York, executed between 1903 and 1908, by co-operation between the U. S. Coast and Geodetic Survey and the City of New York, of which I was in charge by instructions from you dated April 30, 1903.

The formal agreement for co-operation was adopted by the Board of Estimate and Apportionment of New York City May 8, 1903, and approved by you on May 13, 1903. This agreement is as follows:

"Whereas, The Superintendent of the United States Coast and Geodetic Survey has transmitted, under the date of December 22, 1902, to the Chief Engineer of the Board of Estimate and Apportionment, a letter and memorandum which might form a basis for co-operation between the United States Coast and Geodetic Survey and the City of New York in completing the triangulation of the City, and

"Whereas, Section 439 of the Greater New York Charter has been amended so as to permit the City to avail of such co-operation, the said amendment providing that the Mayor, with the approval of the Board of Estimate and Apportionment, shall have power to agree with the proper representative of the United States, upon a basis of co-operation in completing the said triangulation; therefore, be it

"Resolved, That the Board of Estimate and Apportionment, pursuant to the authority conferred upon it by the Greater New York Charter, as amended by the Laws of 1903, does hereby approve of the plan for completing the triangulation of the City, outlined in the memorandum received from the Superintendent of the United States Coast and Geodetic Survey under date of December 22, 1902, in accordance with which the general plan of conducting the work would be as follows:

"1st. That an experienced officer detailed from the Coast and Geodetic Survey shall have charge of all field work. The salary of such detailed officer shall be paid by the Coast and Geodetic Survey, and his subsistence and traveling expenses shall be paid by the City of New York.

"2d. Two field parties for the measurement of angles, under the direction of an officer detailed from the survey—each party to be composed of one observer, one recorder, and one driver or laborer—shall be furnished and paid by the City of New York.

"3d. Two computers, who shall make in the City of Washington, and under the direction of the Chief of Computing Division of the Coast and Geodetic Survey all the necessary computations aside from those made by the field parties, shall be furnished and paid by the City of New York.

"4th. The City of New York will furnish all the material, and pay all the expenses of erecting signals and observing towers, of the permanent marking of stations, of all instruments and tools which may be required, of teams or other means of transportation, and such additional assistance or material as may be required.

"5th. Upon the completion of the field work and computations, the original records and one complete set of computations and results, shall be delivered to the Chief Engineer of the Board of Estimate and Apportionment.

"6th. The work shall be done in conformity with the methods and the highest standard of accuracy of the United States Coast and Geodetic Survey, and the provisions of section 439 of the Greater New York Charter as amended by the Laws of 1903. And be it further

"Resolved, That the Mayor be authorized and requested to forward a copy of this resolution to the Superintendent of the United States Coast and Geodetic Survey, with the request that the said Superintendent indicate his approval of the plan proposed; and be it further

"Resolved, That upon the receipt of such approval, the agreement be considered as made, and the work proceeded with, and the Comptroller be requested to pay such expenses as may be properly certified to him in accordance with the amendatory act herein referred to."

The following quotations from the memorandum of the Superintendent of the Coast and Geodetic Survey, dated December 22, 1902, which is referred to in the formal agreement, are necessary to a full understanding of the agreement.

"It is assumed that in the way of triangulation the needs of Greater New York are, first, a primary triangulation extending over the Boroughs of Richmond, Brooklyn, Queens and the upper part of Manhattan, and connecting with present triangulation in the Borough of The Bronx; second, a secondary triangulation to determine such points within each triangle of the primary scheme that the distances between adjacent points determined by triangulation shall not be less than 5,000

feet nor more than 10,000, these points to be established first in those portions of each borough in which the need is most urgent.

"It is proposed * * * to take such precautions in both the primary and secondary triangulation as are necessary to insure that the maximum error in the length of any line does not exceed one part in 25,000. As a rule, the errors in length would be far below this limit.

"When the field work and computations are completed the original records and one complete set of computations are to be delivered to the Chief Engineer of the Board of Estimate and Apportionment, including lists showing for all points determined by triangulation the final results of the computation, namely, their latitudes and longitudes, and the true azimuths and lengths of the lines joining them, and the rectangular linear co-ordinates of each reckoned for each borough from some one triangulation station in that borough to be selected later, except that the same origin of co-ordinates shall be used for both the Boroughs of Brooklyn and Queens. These co-ordinates are to be referred to the true meridian through the station selected as an origin of co-ordinates in each case."

"The responsibility of the Coast and Geodetic Survey for the accuracy of the work shall end at the points determined directly by triangulation and will not extend to points interpolated by traverse lines or otherwise between triangulation points."

As it was not found to be feasible for the City of New York to furnish properly trained computers for this work the third article of the agreement was subsequently modified by a mutual agreement to the effect that the computers were to be furnished by the Superintendent of the Coast and Geodetic Survey. They were, however, paid by New York City.

ORGANIZATION AND PERSONNEL.

I was instructed by you on April 30, 1903, to take charge of the triangulation of the City of New York whenever the City authorities were ready.

On May 4 I came to New York in answer to a request from Mr. Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, and had interviews with him on the 5th, 6th and 7th, waiting for the approval of the Governor to the amendment of the Charter and making arrangements for an office. The office was obtained on May 16, and the instruments furnished by the Coast and Geodetic Survey arrived from Washington May 25.

Between May 8th and 30th, I was engaged in visiting the old Coast and Geodetic Survey stations in Manhattan, Hoboken, Queens, Brooklyn and Richmond in company with Mr. E. Ankener, Assistant Engineer, Borough of Queens, and in making arrangements for two observers to be assigned to my parties.

On June 5th, Mr. George Wood was assigned from Richmond, and on the 10th, Mr. Camille Mazean from Queens, as Observers, and a laborer was loaned from Brooklyn on June 9.

Mr. Mazean resigned on August 17th and his place was not filled till November 15th, when Mr. Frederick W. Koop, Transitman and Computer, was appointed Observer and placed on the triangulation payroll. Mr. William A. Sherry, Axeman, was appointed September 8th, and acted as Recorder. Mr. William V. Barnes, Axeman, was appointed September 12, and acted as Recorder.

One other Axeman was appointed October 12, another on December 29, and a third on April 21. These five were placed on the triangulation payroll, Mr. Wood remaining on the Richmond payroll until March 14, 1905, when he returned to his regular duties in Richmond.

At first two observing parties were organized with Mr. Koop in charge of one and Mr. Wood of the other. Messrs. Barnes and Sherry as recorders, and the axemen acting as heliotropers for either party as needed.

Several axemen were appointed at different times and several resigned.

The grade of Heliotroper was authorized by the Municipal Civil Service Commission in May, 1906, and an examination was held in June. The successful candidates were certified and appointed in September, 1906.

The following is the list of the Technical Staff, September, 1906:

Mr. Frederick W. Koop, Assistant Engineer and Chief of Party.
Mr. William V. Barnes, Transitman and Chief of Party.
Mr. William A. Sherry, Leveler and Chief of Party.
Harvey P. Hirst, Heliotroper, acting as Recorder.
James B. Wilson, Heliotroper, acting as Recorder.
John H. Sawyer, Heliotroper, acting as Clerk and Computer.
W. A. Cushing, Heliotroper, acting as Heliotroper.
Julius Switzer, Heliotroper, acting as Heliotroper.
Walter J. Broderick, Heliotroper, acting as Heliotroper.
Perry J. Kiernan, Axeman, acting as Heliotroper.
James A. Brennan, Axeman, acting as Recorder.

On the resignation of Mr. Wood, Mr. Barnes and Mr. Sherry were made Observers and each were in charge of parties from March, 1905, to November, 1907, when field work was stopped for want of funds and all the men, except Mr. Koop and two heliotropers, were transferred to other bureaus. Mr. Koop was transferred to the office of the Chief Engineer, Board of Estimate and Apportionment, as Assistant Engineer, at this time.

In September, 1907, Mr. Barnes and the six heliotropers were transferred back to the Triangulation Bureau, and two parties under Mr. Koop and Mr. Barnes were employed until the end of the field work.

Technical Staff, September, 1907:

Mr. Frederick W. Koop, Assistant Engineer and Chief of Party.
Mr. William V. Barnes, Transitman and Chief of Party.
James B. Wilson, Heliotroper, Recorder.
Harvey P. Hirst, Heliotroper, Recorder.
John H. Sawyer, Heliotroper, Computer and Draftsman.
Julius Switzer, Heliotroper.
Walter J. Broderick, Heliotroper.

Mr. Koop was on the payroll of the Board of Estimate and Apportionment, but served the Triangulation Bureau.

With this force two observing parties were run until August 1, 1908, after which date the whole force, with the exception of Mr. Barnes and Broderick, who were transferred to other bureaus, was employed on office work.

RECONNAISSANCE AND SELECTION OF BASES.

The first work to be done on the Primary Triangulation of Greater New York was the selection of the stations to form a scheme for a series of triangles covering the whole city together with the selection of one or more base lines of suitable length strongly connected with the primary triangulation.

The primary triangulation is shown on Map No. 1 and extended from the line Highbridge-Jackson, through Queens and Brooklyn, to the southern border of Richmond. These stations were selected and many of them occupied in 1904.

A reconnaisance made by Mr. Koop revealed a very fine site for a base on Ocean Parkway, in the Borough of Brooklyn, perfectly straight, and nearly level, but obstructed by trees along the curb line. Further study showed that a base nearly 13,000 feet long could be obtained here by prolonging the east line of the Parkway beyond the angle south of Neck road down Hubbard street to Avenue Y.

The connection sought was to so select the ends of the base that by building towers of reasonable height, both ends of the base would see each other, and the stations, Prospect Water Tower, Centennial Tower, Fort Tompkins, sides of the original triangulation, and also the flagstaff of the schoolhouse on Avenue K, near Flatbush avenue. These form the base figure. After several days' labor, climbing trees and using flags and heliotropes, Mr. Koop found that by building 52 feet at each end all the conditions were fulfilled.

The base was then divided into four nearly equal sections and the base ends and the ends of the sections marked by granite posts 6″x6″x4′ set in a bed of concrete 3′x3′x4′ and marked by brass bolts, each with a fine hole drilled in its top, sunk in top of each post.

Unionport base in the Bronx was connected with the primary triangulation of the Bronx and divided into four sections between the stations Ludlow and Crosby marking the ends of the base, and the sections marked in the same manner as at Ocean Parkway.

The triangulation of the Bronx had not been intended in the first reconnaissance which begun at the line Highbridge-Jackson on its southern borders, but at the request of Chief Engineer Briggs, who agreed to build the necessary signal towers, the work was undertaken.

The scheme of the triangulation from the Unionport base to cover the Borough was laid out by me after Assistant Engineer E. H. Holden had designated the stations most useful to him in his work of monumenting in the borough.

Mr. Holden determined the lines of intervisibility and built the signal towers, and to his ability and zeal we are indebted for the rapid prosecution of the work.

RICHMOND.

The points best suited for the work of the Topographical Bureau of Richmond were selected by Mr. George W. Tuttle, Principal Assistant Engineer, and the lines of intervisibility determined by him in the summer and fall of 1905. I then drew up a scheme covering the whole borough and 17 tripod and scaffold signal towers were erected under the direction of Mr. Tuttle.

BROOKLYN.

The selection of the stations for the triangulation of Brooklyn was made by our parties, and all signal towers erected in the Borough, except those at Avenue U, Duck Point and Ruffle Bar, were done by our parties.

QUEENS.

The selection of the stations in Queens and the determination of the intervisibility of the stations and the heights necessary to build at each location were determined by Messrs. Koop, Barnes and Sherry, and only three towers were erected by the Queens engineers.

STATIONS AND SIGNALS.

The stations and signals used in this triangulation, except the tripod and scaffold signals mentioned below and illustrated by Plate 6, were necessarily the towers of churches and public buildings, the flagstaffs of schoolhouses and armories, which furnished poor foundation for the tripod of the theodolite, rendering the use of a position theodolite impossible, and requiring great care to get reliable observations with a repeating theodolite, and necessitating many eccentric stations. Many of these were tripods of 10 to 16 feet high, erected by our parties on the spot with scaffolds for the observer to stand on independent of the tripods. When the wind blows strongly the open roofs and towers are exposed to its full force, shaking the instrument and sometimes the towers themselves so as to render accurate pointings impossible.

By the use of wind shield of canvas and other contrivances the observers succeeded in getting good observations where seemingly impossible.

On the tripod and scaffold signals, of which Plate 6 shows an illustration, a position instrument can be used, increasing the accuracy of the measures and saving time in the observations.

On the towers a tent can be secured to protect the instrument from the wind, while sights can be taken through small openings left for the purpose.

The condition of the atmosphere in a large city is very unfavorable for observations owing to the smoke and steam rising from the numerous chimneys of power plants and manufactories and necessitates the use of heliotropes on many short lines that would be readily visible without their use in the open country, and the results cannot therefore be fairly compared with those obtained by the Coast and Geodetic Survey in the open country. Many large chimneys were in line with some of the stations and smoke and hot gases arising from them rendered the observations very difficult and in some cases impossible. By taking advantage of a favorable wind and watching for a chance some observations were obtained on these obstructed lines, but a few of them were lines bent from horizontal refraction and were rejected.

The line Highbridge-Dunwoodie of The Bronx was rejected from this cause in the primary triangulation. At Jerome Water Tower the

large chimney on the north side of the tower and nearly on the level of the observing platform rendered it impracticable to observe the directions to City Line West, and Police, but the lines in the other direction were observed *on* Jerome Water Tower.

At many of the schoolhouses which were occupied in cold weather, some one line passing over a chimney of the house in which a fire was burning was impossible to observe. In some cases the fire was banked, at our request, on Saturdays when there was no school, and the lines observed at that time.

The following tripods and scaffold towers were erected in the several boroughs.

In The Bronx one tower 30 feet high, three 52 feet, four 68 feet, seven 84 feet and two 86 feet.

IN BROOKLYN.

One tower 16 feet, one 30 feet, three 52 feet, one 68 feet and one 73 feet.

IN RICHMOND.

Three towers 15 feet, five 30 feet, one 52 feet, four 68 feet, one 78 feet and four 84 feet.

IN QUEENS.

One tower 30 feet, five 52 feet, four 68 feet and four 84 feet.

MARKING THE STATIONS ON THE GROUND.

The stations were marked on the ground from the position of the theodolite on the tripod by the use of the vertical collimator (see Plate 3) and were marked permanently by a bronze plate with a split stem inserted in a granite post 6″x6″x24″ incased in concrete 3′x3′x4′. A small hole drilled in the bronze plate marks the triangulation station.

INSTRUMENTS USED.

The instruments furnished by the United States Coast and Geodetic Survey for use in this triangulation were as follows:

Theodolite No. 63, Gambey repeater, 10-inch circle.

Theodolite No. 29, 6-inch repeater by Gambey.

Theodolites Nos. 167 and 168, twin instruments, were 12-inch position instruments.

Theodolite No. 133 is an 8-inch position instrument.

Theodolite No. 128, 4-inch Fauth.

Vertical Collimator No. 1.

Eight wooden heliotropes.

Four telescopic heliotropes.

Theodolite No. 63 is an instrument made by Gambey, of Paris, thirty or forty years ago, but has been regraduated in the Coast and Geodetic Survey Instrument Division. It has steel spindles and reads by two verniers to 5 seconds. Telescope has a clear aperture of two inches (see Plate No. 1).

No. 29 is a six-inch theodolite made by Gambey and reconstructed in the instrument division. It has steel spindles and the telescope tube and all the upper works are of aluminum. The axis extends below the leveling screws and stand, and the stand and outer covering of the axis is of bronze.

This design lowers the centre of gravity and increases the stability of the instrument, while the very light upper works decrease the friction on the centers. It reads by two verniers to 10 seconds.

Theodolites Nos. 167 and 168 are exactly alike; they are Position Theodolites with 12-inch circles reading by three microscopes to single seconds (see Plate No. 4), also in Appendix 8 of U. S. Coast and Geodetic Survey Report for 1894 for a full description and test of these theodolites.

Theodolite No. 133 is a position instrument with 8-inch circle reading by two microscopes to two seconds (see Plate 9).

Theodolite No. 128 is a 4-inch instrument reading to minutes by two verniers and was used for reconnaissance angles.

Vertical Collimator No. 1 is an instrument designed for plumbing down from high tripods to a mark on or below the ground to mark the triangulation station. It consists of a short telescope with cross hairs in its diaphragm, mounted vertically on a stand with a very delicate level attached to the telescope. This telescope being over exactly the same spot occupied by the theodolite in measuring the angles, is leveled carefully, and the observer looking down the telescope can fix a point on a bolt or stone which is accurately under the telescope (see Plate No. 3).

The heliotropes used were of two kinds, wooden and telescopic, and were mounted on tripods like a theodolite. The heliotroper is "posted" at his station by the observer and has a mark showing the station over which he carefully plumbs his tripod and heliotrope. He then directs his telescope carefully on a light shown him from the station being occupied and directs the reflection of the sun from his mirror through the vanes in the direction his telescope is pointing. The heliotroper is required to keep up a steady light from his heliotrope during the prescribed hours whenever the sun is not obscured (see Plates 7 and 8).

Theodolites Nos. 167 and 168 were used on the tripod and scaffold towers, as was No. 133.

No. 63 was used on most of the long lines involving stations which were located on roofs and unsteady towers where Nos. 167, 168 and 133 could not be used.

No. 29 was used on the shorter lines, principally at the secondary stations.

No. 128 was used on reconnaissance.

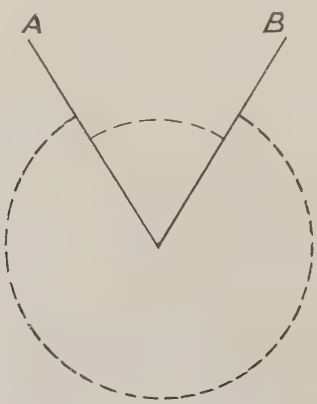
Two C. L. Berger & Sons transits with 7-inch limbs reading to 10 seconds were purchased in August, 1904, and used as transits in running out base lines, setting monuments, etc., and on the standardization of the tapes.

Both these instruments were used also at several secondary stations for the measurement of angle, but did not prove satisfactory in comparison with No. 29, 6-inch, while the instrument in its box was much larger and weighed twice as much as No. 29.

RECORDS AND METHODS OF OBSERVING.

The directions under which the observers operated were as follows:

With Repeating Theodolites—Measure all angles from left to right. Each shall consist of three repetitions telescope direct and three repetitions telescope reversed, on the main angle, and three repetitions telescope reversed and three repetitions telescope direct on explement measured at once. This makes twelve repetitions, direct and reversed for each set. The sum of the result of the six repetitions on angle direct and the result of the six repetitions on the explement should equal 360 degrees within 3 seconds; usually with the theodolite in good order it will equal 360 degrees within 1 second.



Referring to sketch. Measure first the angle A — B, then immediately afterward its explement B — A. The sum of the two angles should equal 360 degrees within 3 seconds.

Measure each separate angle around the horizon and then close the horizon with another angle (even if not needed in the triangulation). The sum of all these angles shall equal 360 degrees within 3 seconds.

Measure four sets of 12 repetitions, as explained above, on each primary angle and three sets of 12 repetitions on each secondary angle, and the mean of these sets (corrected for error of closing the horizon and again for reducing observations to centre of station) taken from the abstract will be the final value of the angle to enter in the list of directions (see p. 27). (In the final computation of the triangle sides these directions have each a correction for closing the triangles and for discrepancies of the lengths of the sides of the triangles which are obtained by the *least-square* adjustment.)

Use the form of record book furnished by the Coast and Geodetic Survey, and always read the limb after one repetition has been made, which gives the approximate angle, as a guide to getting the final angle by dividing the arc passed over in the six repetitions by six.

Do not reset the circle to 0° 0′ 0″ after a set is finished, but use the last reading on one set, for the first reading of the next set.

Measure one set on each angle in its order from left to right in succession round the horizon, rather than take more than one set on any angle.

The Recorder shall keep a record in the Record Book furnished and take out the means and resulting angles at once, and when the last reading on the angle has been given by the Observer, shall inform the Observer how near the sum of the direct angle and in its explement is to 360 degrees.

The Observer shall check all the means and results for an angle in the Record Book and shall make an abstract on the forms furnished of all angles measured. This abstract shall be checked by the Engineer in charge of the triangulation.

We give below specimens of (a) the record for repeating theodolite; (b) abstract for repeating theodolite; (c) example of computation of "reduction to centre," and (d) list of directions for station Idlewild, Queens.

The average error in closing the horizon on this survey for all stations primary and secondary, observed with the repeating theodolites, occupied in 1903 to 1908, 138 in number, was 1″.26 to 0″.22 to an angle where the stations averaged 5.72 directions to a station.

(*a*)

HORIZONTAL

Station ; Idlewild Ecc. No. 1. State ; New York.

Observer ; W. V. Barnes.

OBJECTS OBSERVED.	Time h. m.	Tel. D. or R.	Reps.	Circle. ° ′		A ″ Verniers.	B ″ Verniers.
Circle set to	..	.....	..	0	0	0	0
Hollis v-ft.....	..	.....	1	3	35	50	
Metropolitan ft.....	2.25	3 D. & 3 R.	6	21	34	40	40
Metropolitan.....	..	.....	..	..	..	..	..
Hollis	2.42	3 R. & 3 D.	6	359	59	55	55
Metropolitan.....	..	.....	1	117	5	10	
Far Rockaway school-house.....	2.58	3 D. & 3 R.	6	342	32	10	10
Far Rockaway school-house.....	..	.....	..	..	..	..	..
Metropolitan.....	3.15	3 R. & 3 D.	6	359	59	50	50

ANGLES.

County : Queens. Date : April 14, 1908.
Instrument : Theod. No. 63.

Mean of Verniers. ′	Arc Passed Over.			Angle Mean D. and B.			Mean of 12 Repetitions.		
0									
40	21°	34′	40″	3°	35′	46″.67 + 0.41			
..	..	..	..	..	..	..	3°	35′	47″.08
55	2,138	25	15	356	24	12.50—0.42			
				Sum 359	59	59.17			
				Correction		+ 0.83			
10	..	..	..	117	5	23.50			
..	..	..	..	..	..	..	117	5	22.92
50	..	..	..			23.33*			

*To shorten the computation and obtain the same result of closing the horizon we subtract the last reading from the preceding and divide by 6, giving 23.33. This last form was used in the New York triangulation.

(*b*)

ABSTRACT OF HORIZONTAL ANGLES.

Station: Idlewild Ecc. No. 1.
Observer: W. V. Barnes.

State: New York.
Repeating Theodolite No. 63.

Angle Center — Hollis = 54° 34′ 20″. Distance = 1^{m}.270.

Date, 1908.	Hour.	Stations Observed.	Tel. D. or R.	No. of Reps.	Angle. ° ′ ″	Mean of D. & R. ″	Corr. ″	Mean Angle. ° ′ ″
April 14	2.33	Hollis.....	D. & R.	12	3 35 47.08			
" 28	4.11	Metropolitan.....	"	12	47.08			
" 28	4.46	....	"	12	47.08	47.08	+0.03	3 35 47.11
								*= +24.99
								3 36 12.10
April 14	3.6	Metropolitan.....	D. & R.	12	117 05 22.92			
" 14	5.25	Far Rockaway schoolhouse.....	"	12	23.75			
" 23	3.2	....	"	12	25.00	23.89	+0.04	117 05 23.93
								*= −43.04
								117 04 40.89
April 14	3.43	Far Rockaway schoolhouse.....	D. & R.	12	67 52 49.58			
" 22	2.45	Seaside Hotel.	"	12	49.79			
" 22	3.52	.....	"	12	50.00	49.79	+0.03	67 52 49.82
								*= −40.13
								67 52 09.69
April 14	4.16	Seaside Hotel.....	D. & R.	12	4 58 26.46			
" 22	3.19	Enterprise.....	"	12	27.50			
" 22	4.33	....	"	12	25.84	26.60	+0.04	4 58 26.64
								*= −28.07
								4 57 58.57

April	24	1.55	Enterprise	D. & R.	12	5	25	39.58				
"	24	3.04	Belle Harbor church	"	12			40.00				
"	24	4.14		"	12			39.38	39.65	+0.04	5	25 39.69
											*=	+83 87
											5	26 13.56
April	24	2.30	Belle Harbor church	D. & R.	12	34	53	17.50				
"	24	3.36	Duck Point	"	12			18.75				
"	24	4.52		"	12			19.17	18.47	+0.04	34	53 18.51
											*=	−18.89
											34	52 59 62
April	21	2.24	Duck Point	D. & R	12	36	05	26.25				
"	21	3.28	Prospect water tower	"	12			24.58				
"	21	4.47		"	12			24.16	25.00	+0 03	36	05 25.03
											*=	+39.12
											36	06 04.15
April	21	2.56	Prospect water tower	D. & R.	12	90	03	08.12				
"	21	4.05	Hollis	"	12			09.58				
"	21	5 24		"	12			10.00	09.23	+0.04	90	03 09.27
											*=	+32.15
											90	03 41.42
						359	59		59.71		360	00 0.00
								§=	$\frac{+0.29}{8}$	=+0.036		

* Reduction to center.

§ Correction to close horizon.

(*c*)

REDUCTION TO CENTER.

$$c = \frac{d \sin a}{s \sin 1''} \text{ in seconds.}$$

Eccentric Station No. 1, Idlewild.

$d = 1^{m}.270.$

$\log d = 0.10380$
$\text{colog} \sin 1'' = 5.31443$
$\text{Sum} = \overline{5.41823}$

Stations.	a ° ′	$\log \sin a$	$\log s$	$\log \frac{\sin a}{s}$	Logarithm of Reduction in seconds.	Reduction $= c$ ″
Center	0 0					
Hollis	54 34	9.91105	3.98490	5.92615	1.34438	+22.10
Metropolitan	58 10	9.92921	3.67449	6.25472	1.67295	+47.09
Far Rockaway schoolhouse	175 16	8.91655	3.72701	5.18954	0.60777	+4.05
Seaside Hotel	243 8	n9.95039	3.81138	n6.13901	n1.55724	—36.08
Enterprise	248 7	n9.96752	3.57854	n6.38898	n1.80721	—64.15
Belle Harbor church	253 33	n9.98185	3.91890	n6.06295	n1.48118	—30.28
Duck Point	288 26	n9.97713	3.70368	n6.27345	n1.69168	—49.11
Prospect water tower	324 31	n9.76378	4.17972	n5.58406	n1.00229	—10.05

To obtain the Reduction to Center for any *angle* from the *c's* say minus left-hand station *c* plus right-hand station *c* = Reduction for the angle.

Example: To get reduction from eccentric to center for angle Prospect W. T.—Hollis we have—[—10.″05] + 22.10 = + 32″.15.

(*d*)

STATE: NEW YORK.

Station: Idlewild. Computed by A. T. M.
Observer: W. V. Barnes. Checked by J. H. S.

Stations Observed.	Directions After Local Adjustment.			
	°	′	″	
Far Rockaway schoolhouse	0	0	0.00	Observed from center.
Edgemere Hotel	20	59	55.74	Observed from Ecc. No. 2.
Arverne Hotel	48	04	39.31	Observed from center.
Seaside Hotel	67	52	09.69	Observed from Ecc. No. 1.
Enterprise	72	50	08.26	Observed from Ecc. No. 1.
Belle Harbor church	78	16	21.82	Observed from Ecc. No. 1.
Ruffle Bar	93	54	01.25	Observed from center.
Duck Point	113	09	21.44	Observed from Ecc. No. 1.
Canarsie Park	129	10	17.16	Observed from center.
Prospect water tower	149	15	25.59	Observed from Ecc. No. 1.
Aqueduct schoolhouse	181	24	23.96	Observed from center.
Hollis	239	19	07.01	Observed from Ecc. No. 1.
Metropolitan	242	55	19.11	Observed from Ecc. No. 1.
Springfield schoolhouse	263	05	13.19	Observed from center.
Jager	284	41	37.59	Observed from Ecc. No. 2.
Bayhead Hotel	314	24	54.31	Observed from center.

To obtain any *angle* for computing triangle sides take the difference of the *Directions* from this list.

RECORD AND METHOD OF OBSERVING WITH POSITION THEODOLITE.

The instrument used on the tripod and scaffold signal towers was a 12-inch Position Theodolite reading by three microscopes to seconds and having an arrangement for changing positions.

The method of observing with this theodolite was to set the microscope A. to read the setting shown in the following table for the I., II., III., etc., positions wished and then bring the telescope wires to bisect the signal at the initial station by turning the lower plate by means of the "changing of position" arrangement without altering the reading of microscope A, and keeping the alidade clamped. Then with the telescope direct point successively on the signals in their order from left to right reading the three microscopes at each pointing telescope D.

After reading on the last or right hand signal unclamp and reverse the telescope in its Y's, and also turn the alidade carrying the microscopes 180°, and point on the right hand signal again telescope R. and read all the microscopes. Then point on each signal in the reverse order (right to left) ending at the initial signal.

The mean of the readings direct and reverse on each signal gives the result for that signal independent of collimation and inequality of pivots. Observing in the order named first from left to right and then from right to left serves to correct for "Twist of tripod" as the means of the times of observing direct and reverse will be nearly the same for each signal.

Taking the difference of the readings of each signal from the initial reckoned as zero, we have the *direction* of each signal.

Sixteen positions were observed at each primary station and the mean of these is the final result for the direction.

The positions were so selected as to correct for the run of the microscopes and are divided into sets of four positions each which correct for periodic errors of graduation, so that the mean of each set of four positions, should be equal, except for errors of observation and changes in atmospheric conditions.

The settings for the different positions on the initial are as follows:

Position.	Setting. °	′	″	Position.	Setting. °	′	″
I.	0	0	40	IX.	128	00	40
II.	15	01	50	X.	143	01	50
III.	30	03	10	XI.	158	03	10
IV.	45	04	20	XII.	173	04	20
V.	64	00	40	XIII.	192	00	40
VI.	79	01	50	XIV.	207	01	50
VII.	94	03	10	XV.	222	03	10
VIII.	109	04	20	XVI.	237	04	20

The following are examples of record and abstract for positions theodolite:

(*e*)

HORIZONTAL

Station: Ft. Tompkins 2. Observer; F. W. Koop.

Position.	Objects Observed.	Time. h. m.	Tel. D. or R.	Mic.	°	′
I	Bogart p. distinct unsteady.....	3.30	D.	A	0	0
				B		
				C		
	Bogart.....	4.00	R.	A	180	0
				B		
				C		
	Centennial T.....	3.40	D.	A	208	37
				B		
				C		
	Centennial T.....	3.51	R.	A	28	37
				B		
				C		
	Sandy Hook lighthouse.....	3.42	D.	A	256	42
				B		
				C		
	Sandy Hook lighthouse.....	3.49	R.	A	76	43
				B		
				C		

DIRECTIONS.

Instrument : Theodolite No. 168. Date ; June 20, 1906.

Backward	Forward.	Mean.	Mean. D. and R.	Direction.	Remarks.
"	"			"	
33	33				
35	35				
39	39	35.67			
43	43				
33	33				
52	52	42.67	39.17	0.00	
38	38				
35	35				
54	54	42.33			
50	50				
54	54				
55	55	53.00	47.16	8.49	
53	53				
52	52				
63	63	56.00			
4	4				
1	1				
3	3	2.67	59.34	20.17	

(*f*)

TRIANGULATION STATION, FT. TOMPKINS 2.

Final Directions with Theodolite No. 168.

Observer F. W. Koop.

Bogart—Centennial Tower.

Date 1906.	Position.	Directions. ° ′ ″	Mean.
June 20	I.	208 37 8.49	
" 20	II.	8.50	
" 20	III.	8.00	8.46
" 20	IV.	8.83	
" 22	V.	9.32	
" 22	VI.	8.50	
" 22	VII.	8.67	8.96
" 22	VIII.	9.33	
" 23	IX.	9.00	
" 23	X.	8.16	
" 25	XI.	10.83	9.66
" 25	XII.	10.67	
" 25	XIII.	8.66	
" 26	XIV.	8.16	
" 26	XV.	10.33	8.95
" 23	XVI.	8.66	
Mean...	.....	208 37 09.01	

Bogart—Sandy Hook Lighthouse.

Date.	Position.	Directions. ′ ″	Mean.
June, 20	I.	256 42 20.17	
" 20	II.	20.66	
" 20	III.	20.16	20.41
" 20	IV.	20.66	
" 22	V.	21.49	
" 22	VI.	19.67	
" 22	VII.	19.16	20.24
" 22	VIII.	20.66	
" 25	IX.	19.84	
" 25	X.	17.50	
" 25	XI.	17.50	18.92
" 25	XII.	20.83	
" 25	XIII.	18.00	
" 26	XIV.	20.16	
" 26	XV.	19.67	19.12
" 26	XVI.	18.66	
Mean...	.....	256 42 19.67	

MEASUREMENT OF BASES—OCEAN PARKWAY BASE LINE.

In the early part of September, 1904, after the stations around the base had been occupied, the Ocean Parkway Base Line was prepared for measurement with the four tapes purchased in August, each 150 feet in length.

The plan was to use all four tapes in the measurement, and, by dividing the base into sections, measure each with at least two tapes.

Stakes were set 150 feet apart, of 4″x4″ scantling, with an intermediate stake 3″x2″ of the proper height, in which was set a wire nail to support the middle of the tape; these stakes and the nail in the intermediate stakes were carefully leveled twice to obtain the true grade of each tape length, and the base was connected by a double line of levels with the Coast and Geodetic Survey bench mark K at Bath Beach, the height of which above mean sea level is given as 8.2966 meters, from which we obtain the height of each section of the base to reduce it to mean sea level. Many of the stakes when the line crossed intersecting streets could not be set until an hour or two before the section was measured.

All measurements were made at night. The tapes were stretched uniformly at a tension of 15 kilogrammes by means of a stretching apparatus carrying a delicate spring balance reading directly to 25 grammes (see Plate No. 5).

The thermometers are lashed to each tape, one near each end, and are read to tenths of a degree at each application of the tape (they had all been standardized at the Bureau of Standards in Washington).

The mean of all the thermometer readings for each tape for the whole section gives the temperature of the tape for that section. Each section was measured both ways, using a different tape each time. The tapes were standardized on the night of September 27, and the first section of 3,300 feet measured on the 28th, using tapes Nos. 245 and 243.

Section II. of 3,300 feet was measured on September 30, using Nos. 244 and 242.

Section III. of 3,300 feet was measured on October 3, using 243 and 244.

Section IV. or 3,030 feet on October 4, using Nos. 245 and 242.

The tapes were standardized again on October 6, after all the sections had been measured.

UNIONPORT BASE LINE.

Unionport Base Line extends from triangulation station Crosby to triangulation station Ludlow of The Bronx triangulation and is di-

vided into four sections. Both ends and the ends of the sections are marked like Ocean Parkway base by granite monuments set in concrete 3′x3′x4′ deep.

These monuments were set by Mr. Holden's parties before the ground was frozen.

The greater portion of the base runs over a salt marsh covered at high tide and crossed by several narrow creeks, so that boardwalks for operators had to be laid for over a mile on the marsh and bridges constructed over the creeks, a section at a time, before the stakes could be set and the measurement made. The preparation of the board platforms and bridges was done by Mr. Holden, and the setting of the stakes and clearing the line of the numerous falls of snow was under the direction of Mr. Koop.

Owing to the unprecedented fall of snow and the extreme cold of the winter this work was arduous in the extreme, as some sections were cleared of deep snow three or four times before the staking and measurement could be finished.

The standardization and measurement were done by the parties of Mr. Koop and Mr. Holden under my personal supervision.

Mr. Koop made the front contacts and Mr. Holden the rear contacts.

The base was measured with the same four 150-foot New York tapes used on the Ocean Parkway base and were standardized by comparison with the two 100-meter and one 50-meter U. S. C. and G. S. tapes whose length is probably correct within one part in a million. One standardization was made on December 1, 1904, before the measurement was begun at temperature 33° Fahr., and the last after the last section had been measured on February 27, 1905, at temperature 27° Fahr. The measurement of the first section was made at temperature 32° Fahr. on December 7, 1904, using tapes Nos. 242 and 243.

The second section was measured at temperature 27° on January 11 and 18, 1905, using tapes Nos. 244 and 245 and tape No. 85, U. S. C. and G. S., of 100 meters.

The third section was measured at temperature 18° on January 23, 1905, with tapes Nos. 242 and 244.

The fourth section was measured at temperature of 31° on February 21, 1905, with tapes Nos. 243 and 245 and 50 meters tape, U. S. C. and G. S., No. 248.

Mr. Holden leveled each section once after the measures had been made and connected with the United States Engineers B. M. at Westchester Bridge for height above mean sea level.

LENGTH OF BASES AND PROBABLE ERRORS OF RESULTS.

Ocean Parkway Base Line.

No. of Section.	Length of Section. Feet.
I.	3299.9751
II.	3299.9668
III.	3299.6753
IV.	3029.8574
Total length	12929.4746

Unionport Base Line.

I.	2700.2845
II.	3478.7432
III.	2400.1379
IV.	3374.4441
Total length	11953.6097

The probable error of the Ocean Parkway Base is one part in 520000.

The probable error of the Unionport Base Line is one part in 590000.

These include all the errors arising from all causes, including the standardization of the tapes.

STANDARDIZATION OF THE FOUR NEW YORK TAPES.

The four New York tapes, Nos. 242, 243, 244 and 245, used in the measurement of both bases, were compared before the first and after the last measurement with tapes Nos. 85 and 88, 100 metres long, and with tape No. 248, 50 meters long, obtained from the Coast and Geodetic Survey office at Washington. These tapes have been many times compared with the standard bar in ice and ten to fifteen bases had been measured with them during the last ten years. Their lengths are probably correct within one part in a million and had been found constant in length during many years.

In Appendix No. 3, U. S. C. and G. S. Report of 1901, on "Measurement of nine bases along the 98th meridian," we find that the equations of these tapes are as follows:

$$T\ 88 = 100^{m} + 26^{mm}.01 \pm 0^{mm}.045 + (1^{mm}.053 \pm 0\ \ .005)\,(t - 15°.52\ C)$$
$$T\ 85 = 100^{m} + 23^{mm}.32 \pm 0^{mm}.054 + (1^{mm}.068 \pm 0^{mm}.001)\,(t - 1\ °.97\ C)$$
$$2\ T\ 248 = 100^{m} + 4\ ^{mm}.19 \pm 0^{mm}.034 + (1^{mm}.054 \pm 0^{mm}.006)\,(t - 17°.74\ C)$$

The operation of comparing the four New York tapes with these three C. and G. S. tapes is described in detail, illustrated with cuts, on pages 44, 45 and 46 in Report of Chief Engineer of the Board of Estimates and Apportionment for the year 1904.

Four standardizations were made, one on September 27, before the measurement of the Ocean Parkway Base was begun, and again on October 6, after it was finished.

One standardization was made on December 1, 1904, before the Unionport Base measurement was begun, and another on February 27, after the measurement was finished.

EQUATIONS OF THE NEW YORK BASE TAPES.

In Meters.

$$T\ 242 = 45^{m}.71141 + (0^{mm}.297)\ (t - 40^{\circ}.70F)$$
$$T\ 243 = 45^{m}.71174 + (0^{mm}.297)\ (t - 41\ .32F)$$
$$T\ 244 = 45^{m}.71171 + (0^{mm}.297)\ (t - 40\ .91F)$$
$$T\ 245 = 45^{m}.71201 + (0^{mm}.297)\ (t - 41\ .26F)$$

The probable error of the length at any temperature t is, in millimeters.

$$\text{For T 242} \pm \sqrt{[0.155]^2 + \left[\ (0.0018)\ (t - 40^{\circ}.70F)\ \right]^2}$$
$$\text{T 243} \pm \sqrt{[0.199]^2 + \left[\ (0.0018)\ (t - 41\ .32F)\ \right]^2}$$
$$\text{T 244} \pm \sqrt{[0.217]^2 + \left[\ (0.0018)\ (t - 40\ .91F)\ \right]^2}$$
$$\text{T 245} \pm \sqrt{[0.171]^2 + \left[\ (0.0018)\ (t - 41\ .26F)\ \right]^2}$$

EQUATIONS OF NEW YORK BASE TAPES.

In Feet.

$$T\ 242 = 150^{ft} - 0^{ft}.02848 + (0^{ft}.000974)\ (t - 40^{\circ}.70F)$$
$$T\ 243 = 150^{ft} - 0^{ft}.02739 + (0^{ft}.000974)\ (t - 41\ .32F)$$
$$T\ 244 = 150^{ft} - 0^{ft}.02749 + (0^{ft}.000974)\ (t - 40\ .91F)$$
$$T\ 245 = 150^{ft} - 0^{ft}.02651 + (0^{ft}.000974)\ (t - 41\ .26F)$$

These four New York tapes, Nos. 242, 243, 244 and 245, were intended to be kept as standards, one in each borough, to standardize the tapes used in field work in these boroughs, thus guaranteeing the same standard in all parts of the City.

Tape No. 242 has been delivered to The Bronx Borough.

Tape No. 243 has been delivered to Richmond Borough.

Tape No. 244 has been delivered to Brooklyn Borough.

Tape No. 245 has been delivered to Queens Borough.

With each tape was delivered two thermometers. To use these tapes for comparison with other tapes to standardize them, it is necessary that they should be used under the same conditions as when they were standardized by comparison with U. S. C. and G. S. tapes. These conditions are:

1. All comparisons to be made at night.
2. Tapes to be supported at each end and in the middle at a tension of 15 kilogrammes as shown by an accurate spring balance.
3. t in formula denotes the temperatures of the tape at the time of comparison indicated by thermometers lashed to the tape near the ends (about one meter from end usually).

SECONDARY TRIANGLES.

After the length of the primary triangle sides had been computed and adjusted to agree with the measured length of the two bases, the secondary triangles contained in each of the primary figures were adjusted, keeping the lengths of the primary sides fixed.

The number of stations determined in each borough was, on an average, one in 7,500 feet.

In The Bronx we have	29 stations.
In Brooklyn we have	44 stations.
In Queens we have	48 stations.
In Richmond we have	41 stations.
In Manhattan we have	7 stations.
In New Jersey we have	10 stations.
In Nassau County we have	2 stations
Total	181 stations.

The number of triangles computed for the whole work was 968.

Map No. 1 shows the primary triangulation and its connection with the two measured bases.

Map No. 2 shows all the triangulation stations determined in all the boroughs, both primary and secondary.

Borough of The Bronx.

BOROUGH OF THE BRONX.

RECTANGULAR CO-ORDINATES.

Parkway=Origin of Axes. True Meridian at Parkway=Axis of Ordinates.

No.	Station.	X in Meters.	X in Feet.	Y in Meters.	Y in Feet.
1	Baychester	— 1881.26	— 6172.10	— 192.64	— 632.02
2	Briggs	+ 931.01	+ 3054.49	+ 2055.57	+ 6743.98
3	Castle	— 814.35	— 2671.75	— 4645.86	— 15242.29
4	City Line East	— 1519.44	— 4985.03	+ 4037.24	+ 13245.51
5	City Line West	+ 1498.08	+ 4914.95	+ 5216.14	+ 17113.29
6	City Island	— 5563.81	— 18253.93	— 180.12	— 590.94
7	Copper Bolt	+ 591.74	+ 1941.40	+ 4862.05	+ 15951.557
8	Crosby	— 2442.32	— 8012.84	— 3014.91	— 9891.42
9	Dunwoodie	+ 678.94	+ 2227.49	+ 8135.74	+ 26692.01
10	Hart Island	— 7330.34	— 24049.62	— 222.72	— 730.71
11	Hunter Island	— 5549.44	— 18206.79	+ 1955.77	+ 6416.56
12	Jackson	— 3259.87	— 10695.09	— 4042.10	— 13261.46
13	Jerome water tower	+ 2588.80	+ 8493.42	+ 2279.89	+ 7479.94
14	Ludlow	+ 1147.65	+ 3765.25	— 3636.95	— 11932.23
15	Maguire	— 2729.97	— 8956.58	+ 3110.90	+ 10206.34

16	McLean	+ 967.00	+ 3172.57	+ 5561.59	+ 18246.65
17	Morris High School	+ 4045.76	+ 13273.46	— 3407.66	— 11179.95
18	Nereid	— 598.88	— 1964.83	+ 5116.04	+ 16784.87
19	North Brother Island lighthouse	+ 3660.30	+ 12008.83	— 6493.66	— 21304.62
20	Parkway	0.0	0.0	0.0	0.0
21	Pilot	— 5992.85	— 19661.54	— 1802.84	— 5914.82
22	Police	+ 242.86	+ 796.78	+ 3680.65	+ 12075.60
23	Protectory	+ 481.98	+ 1581.30	— 1827.29	— 5995.03
24	Prospect Hill	— 3833.96	— 12578.58	+ 3481.50	+ 11422.22
25	Rikers Island	+ 2614.31	+ 8577.12	— 6635.29	— 21769.28
26	Straus	— 715.31	— 2346.81	+ 2119.42	+ 6953.46
27	Throgs Neck lighthouse (New)	— 5358.13	— 17579.13	— 5871.08	— 19262.03
28	Westchester courthouse	— 1021.42	— 3351.11	— 1692.40	— 5552.48
29	West Farms schoolhouse	+ 2204.91	+ 7233.94	— 1883.61	— 6179.81

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
1	Baychester	40	51	21.684	668^{m}.9	73	50	03.325	77^{m}.9
					2194^{ft}.5				255^{ft}.6
2	Briggs	40	52	34.573	1066^{m}.5	73	52	03.405	79^{m}.7
					3499^{ft}.0				261^{ft}.5
3	Castle	40	48	57.325	1768^{m}.2	73	50	48.897	1145^{m}.9
					5801^{ft}.2				3759^{ft}.5

THE BRONX.

POSITIONS.

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
95 51 40.57	275 50 48.03	Parkway	1891m.10	3.2767142
			6204ft.38	
153 15 11.37	333 14 38.81	Straus	2589m.41	3.4132007
			8495ft.42	
208 00 14.28	28 01 08.88	Prospect Hill	4166m.81	3.6191778
			13650ft.92	
239 39 27.33	59 41 09.85	Hunter Island	4251m.02	3.6284932
			13946ft.89	
97 41 56.55	277 41 10.21	Jerome water tower	1672m.90	3.2234694
			5488ft.51	
179 24 16.98	359 24 15.96	McLean	3506m.21	3.5448379
			11503ft.29	
202 56 35.86	22 56 55.09	Police	1764m.77	3.2466886
			5789ft.92	
267 46 18.29	87 47 04.30	Straus	1647m.56	3.2168408
			5405ft.37	
117 13 10.39	297 12 15.66	Ludlow	2206m.20	3.3436454
			7238ft.17	
155 18 26.76	335 17 50.58	Protectory	3102m.38	3.4916955
			10178ft.39	
224 57 14.83	44 58 00.25	Crosby	2304m.40	3.3625588
			7560ft.35	
256 08 18.32	76 09 26.51	Jackson	2518m.95	3.4012195
			8264ft.26	
359 24 31.22	179 24 32.19	College Point school-house	3362m.35	3.5266435
			11031ft.33	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude ° ′ ″	Length of Seconds.
4	City Line East.....	40 53 38.810	1197^{m}.1	73 50 18.736	438^{m}.6
			3927^{ft}.5		1439^{ft}.0
5	City Line West..	40 54 17.028	525^{m}.2	73 52 27.651	647^{m}.2
			1723^{ft}.1		2123^{ft}.4
6	City Island.....	40 51 22.030	679^{m}.5	73 47 26.101	611^{m}.3
			2229^{ft}.3		2005^{ft}.6

THE BRONX.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
22	45	35.10	202	45	12.60	Straus	2079^{m}.58	3.3179747
							6822^{ft}.76	
111	21	06.01	291	19	41.61	City Line West	3239^{m}.63	3.5104959
							10628^{ft}.69	
283	30	47.75	103	31	52.45	Prospect Hill	2380^{m}.31	3.3766328
							7809^{ft}.40	
297	19	39.94	117	21	32.58	Hunter Island	4535^{m}.79	3.6566529
							14881^{ft}.17	
288	00	33.15	108	03	02.26	Prospect Hill	5607^{m}.10	3.7487386
							18395^{ft}.96	
294	48	53.33	114	52	10.37	Hunter Island	7765^{m}.14	3.8901496
							25476^{ft}.13	
324	25	58.40	144	27	00.29	Straus	3806^{m}.41	3.5805155
							12488^{ft}.20	
332	47	20.46	152	49	33.35	Jackson	10409^{m}.28	4.0174206
							34151^{ft}.11	
35	37	55.30	215	35	37.08	Highbridge	8493^{m}.12	3.9290674
							27864^{ft}.51	
47	47	55.76	227	46	28.58	Crosby	4216^{m}.60	3.6249626
							13833^{ft}.96	
91	53	50.49	271	51	15.10	Parkway	5566^{m}.72	3.7455993
							18263^{ft}.48	
154	45	21.35	334	44	33.07	Prospect Hill	4049^{m}.66	3.6074190
							13286^{ft}.26	
179	39	28.34	359	39	27.99	Hunter Island	2135^{m}.93	3.3295878
							7007^{ft}.63	

BOROUGH OF

GEOGRAPHICAL

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
7	Copper Bolt.....	40 54 05.553	171^{m}.3	73 51 48.926	1145^{m}.1
			562^{ft}.0		3756^{ft}.9
8	Crosby	40 49 50.186	1548^{m}.0	73 49 39.411	923^{m}.4
			5078^{ft}.7		3029^{ft}.5
9	Dunwoodie.....	40 55 51.678	1594^{m}.0	73 51 52.664	1232^{m}.2
			5229^{ft}.6		4042^{ft}.6
10	Hart Island	40 51 20.599	635^{m}.4	73 46 10.682	250^{m}.2
			2084^{ft}.6		820^{ft}.9

THE BRONX.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
111 20 06.97	291 19 41.61	City Line West	973^{m}.06.	2.9881381
			3192^{ft}.45	
151 47 07.32	331 46 56.79	McLean	793^{m}.85	2.8997363
			2604^{ft}.49	
257 57 10.38	77 57 43.69	Nereid	1217^{m}.41	3.0854383
			3994^{ft}.12	
343 32 34.77	163 32 44.50	Police	1231^{m}.83	3.0905515
			4041^{ft}.49	
112 07 19.39	292 05 57.78	Protectory	3156^{m}.26	3.4991723
			10355^{ft}.16	
161 25 40.01	341 24 51.81	Straus	5417^{m}.00	3.7337589
			17772^{ft}.27	
321 30 08.62	141 30 31.41	Jackson	1312^{m}.82	3.1182070
			4307^{ft}.14	
314 46 16.29	134 49 10.47	Hunter Island	8774^{m}.09	3.9432021
			28786^{ft}.33	
315 52 40.93	135 54 47.17	Prospect Hill	6482^{m}.91	3.8117703
			21269^{ft}.35	
342 04 17.03	162 06 07.06	Jackson	12798^{m}.88	4.1071756
			41990^{ft}.99	
346 56 49.42	166 57 28.41	Straus	6175^{m}.76	3.7906907
			20261^{ft}.64	
30 25 17.05	210 22 35.89	Highbridge	11390^{m}.29	4.0565349
			37369^{ft}.64	
40 18 10.62	220 17 33.24	Pilot	2070^{m}.18	3.3160084
			6791^{ft}.92	

BOROUGH OF

GEOGRAPHICAL

No	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
10	Hart Island—*Continued*				
*	Highbridge	40 50 33.193	1023^{m}.8	73 55 58.856	1378^{m}.8
			3358^{ft}.9		4523^{ft}.6
11	Hunter Island	40 52 31.271	964^{m}.6	73 47 26.646	624^{m}.0
			3164^{ft}.7		2047^{ft}.2
12	Jackson	40 49 16.876	520^{m}.5	73 49 04.539	106^{m}.4
			1707^{ft}.7		349^{ft}.1
13	Jerome water tower	40 52 41.832	1290^{m}.3	73 53 14.209	332^{m}.7
			4233^{ft}.3		1091^{ft}.5

* This station is not in the Bronx but is included as part of the Bronx Triangulation.

THE BRONX.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
91	26	18.40	271	25	29.06	City Island	1767^{m}.05	3.2472480
							5797^{ft}.40	
140	47	28.31	320	46	38.60	Hunter Island	2813^{m}.79	3.4492916
							9231^{ft}.58	
283	35	36.72	103	40	07.62	Jackson	9989^{m}.13	3.9995275
							32772^{ft}.67	
310	51	23.92	130	54	47.50	College Point schoolhouse	9654^{m}.69	3.9847383
							31675^{ft}.26	
20	56	11.03	200	55	07.00	Jackson	6420^{m}.02	3.8075361
							21063^{ft}.02	
57	56	45.95	237	53	57.46	Protectory	7119^{m}.66	3.8524593
							23358^{ft}.42	
73	09	26.68	253	03	51.58	Highbridge	12537^{m}.35	4.0982058
							41137^{ft}.96	
91	58	54.96	271	56	39.84	Straus	4836^{m}.90	3.6845668
							15869^{ft}.06	
131	41	33.70	311	40	45.76	Prospect Hill	2295^{m}.80	3.3609348
							7532^{ft}.14	
31	18	58.03	211	17	50.80	College Point schoolhouse	4641^{m}.00	3.6666112
							15226^{ft}.34	
198	02	36.29	18	03	29.70	Dunwoodie	6159^{m}.42	3.7895400
							20208^{ft}.03	
200	21	29.83	20	22	00.32	City Line West	3132^{m}.28	3.4958602
							10276^{ft}.49	
259	22	59.40	79	25	58.95	Prospect Hill	6534^{m}.19	3.8151920
							21437^{ft}.59	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
13	Jerome water tower—*Continued.*				
14	Ludlow	40 49 30.031	926^{m}.3 3039^{ft}.0	73 52 12.620	295^{m}.7 970^{ft}.1
15	Maguire	40 53 08.770	270^{m}.5 887^{ft}.5	73 49 27.038	633^{m}.1 2077^{ft}.1

THE BRONX.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
272	45	37.79	92	47	10.14	Straus	3308m.00	3.5195661
							10853ft.00	
311	20	58.16	131	22	10.50	Parkway	3449m.61	3.5377698
							11317ft.60	
332	49	26.16	152	50	25.05	Protectory	4616m.02	3.6642675
							15144ft.39	
44	11	42.57	224	09	54.86	Highbridge	5533m.16	3.7429736
							18153ft.38	
197	55	28.28	17	56	20.28	Straus	6050m.32	3.7817787
							19850ft.09	
200	11	12.42	20	11	30.99	Protectory	1928m.21	3.2851544
							6326ft.14	
260	09	39.57	80	11	19.73	Crosby	3643m.4675	3.5615149
							11953ft.6097	
275	14	35.30	95	16	38.24	Jackson	4426m.11	3.6460219
							14521ft.33	
335	26	10 50	155	27	06.17	College Point schoolhouse	4805m.68	3.6817553
							15766ft.64	
251	27	53.70	71	28	24.55	Prospect Hill	1164m.54	3.0661542
							3820ft.66	
292	17	59.98	112	19	18.77	Hunter Island	3046m.93	3.4858620
							9996ft.47	
14	25	45.49	194	25	21.73	Baychester	3410m.82	3.5328584
							11190ft.33	
41	17	22 92	221	16	06.61	Parkway	4138m.89	3.6168839
							13579ft.01	
63	49	03.70	243	48	07.37	Straus	2245m.41	3.3512960
							7366ft.82	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
16	McLean	40 54 28.230	$870^{m}.8$	73 52 04.902	$113^{m}.1$
			$2856^{ft}.9$		$380^{ft}.9$
17	Morris High School....	40 49 37.431	$1154^{m}.6$	73 54 16.301	$382^{m}.0$
			$3788^{ft}.1$		$1253^{ft}.3$

THE BRONX.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
186	22	39.04	6	22	47.11	Dunwoodie	2590^{m}.21	3.4133357
							8498^{ft}.05	
293	25	04.52	113	27	18.80	Prospect Hill	5232^{m}.20	3.7186845
							17165^{ft}.98	
333	56	46.25	153	57	33.30	Straus	3831^{m}.28	3.5833441
							12569^{ft}.79	
26	17	27.28	206	16	41.95	Jerome water tower	3660^{m}.57	3.5635489
							12009^{ft}.72	
37	05	18.18	217	02	45.12	Highbridge	9086^{m}.27	3.9583855
							29810^{ft}.54	
125	36	23.09	305	35	16.01	Highbridge	2955^{m}.06	3.4705657
							9695^{ft}.06	
194	20	13.02	14	20	53.61	Jerome water tower	5871^{m}.20	3.7687267
							19262^{ft}.43	
220	42	37.99	40	44	50.89	Straus	7294^{m}.95	3.8630224
							23933^{ft}.51	
229	51	42.95	49	53	35.86	Parkway	5289^{m}.64	3.7234261
							17354^{ft}.43	
246	03	13.02	66	04	52.46	Protectory	3898^{m}.47	3.5908940
							12790^{ft}.23	
274	29	32.84	94	30	53.70	Ludlow	2907^{m}.16	3.4634692
							9537^{ft}.91	
274	55	55.15	94	59	18.94	Jackson	7333^{m}.13	3.8652893
							24058^{ft}.78	
313	11	25.45	133	13	41.95	College Point school-house	6717^{m}.60	3.8272143
							22039^{ft}.33	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
17	Morris High School - *Continued*				
18	Nereid	40 54 13.787	425m.3	73 50 58.057	1358m.8
			1395ft.3		4458ft.0
19	North Brother Island lighthouse	40 47 57.395	1770m.4	73 53 59.786	1401m.5
			5808ft.4		4598ft.1
20	Parkway	40 51 27.937	861m.7	73 51 23.645	553m.8
			2827ft.1		1816ft.9

THE BRONX.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth ° ′ ″	To Stations.	Distance.	Logarithms.
42 00 21.29	221 58 17.52	Memorial church.....	6634m.86	3.8218318
			21767ft.87	
296 48 36.07	116 50 06.51	Prospect Hill..... ..	3624m.56	3.5592552
			11891ft.58	
313 15 37.96	133 16 37.54	Maguire.....	2926m.10	3.4662895
			9600ft.05	
319 31 48.85	139 32 14.59	City Line East.....	1418m.18	3.1517318
			4652ft.81	
357 46 46.75	177 46 49.98	Straus.....	2998m.88	3.4769592
			9838ft.83	
30 23 34.44	210 23 10.87	Police.....	1664m.00	3.2211527
			5459m.31	
92 44 15.13	272 43 16.46	City Line West.....	2099m.35	3.3220854
			6887ft.62	
105 53 16 23	285 52 32.39	McLean.....	1628m.03	3.2116633
			5341ft.30	
69 05 31.17	249 03 16.66	Memorial church.....	5167m.61	3.7132896
			16954ft.07	
172 51 06.72	352 50 55.93	Morris High School....	3109m.99	3.4927585
			10203ft.36	
277 40 57.21	97 41 26.37	Rikers Island.....	1055m.53	3.0234720
			3463ft.02	
328 03 00.18	148 03 47.37	North Beach.....	3200m.27	3.5051872
			10499ft.55	
198 38 59.02	18 39 19.01	Straus.....	2236m.87	3.3496411
			7338ft.80	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
20	Parkway—*Continued.*				
21	Pilot	40 50 29.414	907^{m}.3 2976^{ft}.7	73 47 07 840	183^{m}.7 602^{ft}.7
22	Police	40 53 27.256	840^{m}.8 2758^{ft}.5	73 51 34.019	796^{m}.4 2612^{ft}.9

THE BRONX.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
250	35	10.31	70	37	45.38	Hunter Island	5883^{m}.99	3.7696717
							19304^{ft}.39	
320	59	23.09	141	00	31.26	Crosby	3880^{m}.03	3.5888351
							12729^{ft}.73	
321	06	52.43	141	08	23.39	Jackson	5192^{m}.82	3.7154033
							17036^{ft}.78	
14	46	34.71	194	46	21.26	Protectory	1889^{m}.79	3.2764131
							6200^{ft}.09	
17	30	47.82	197	30	15.80	Ludlow	3813^{m}.73	3.5813499
							12512^{ft}.21	
50	43	01.58	230	41	45.27	Jackson	3533^{m}.20	3.5481676
							11591^{ft}.84	
71	11	51.99	251	10	12.88	Crosby	3751^{m}.72	3.5742301
							12308^{ft}.77	
89	49	48.55	269	46	47.81	Protectory	6474^{m}.88	3.8112318
							21243^{ft}.00	
106	47	22.09	286	44	34.77	Parkway	6258^{m}.16	3.7964464
							20531^{ft}.98	
126	39	58.18	306	37	30.81	Straus	6575^{m}.45	3.8179256
							21572^{m}.96	
165	14	11.15	345	13	59.20	City Island	1678^{m}.49	3.2249182
							5506^{ft}.85	
173	19	05.86	353	18	53.55	Hunter Island	3784^{m}.68	3.5780288
							12416^{ft}.90	
59	09	24.72	239	08	19.14	Jerome water tower	2732^{m}.31	3.4365300
							8964^{ft}.25	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
22	Police—*Continued.*				
23	Protectory	40 50 28.699	885^{m}.2 2904^{ft} 2	73 51 44.218	1035^{m}.9 3398^{ft}.6
24	Prospect Hill	40 53 20.768	640^{m}.6 2101^{ft}.7	73 48 39.874	933^{m}.5 3062^{ft}.7
25	Rikers Island	40 47 52.818	1629^{m}.2 5345^{ft}.1	73 53 15.164	355^{m}.5 1166^{ft}.3

THE BRONX.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
140 43 59.03	320 43 23.93	City Line West	1983m.26	3.2973789
			6506ft.75	
158 56 32.10	338 56 11.84	McLean	2015m.52	3.3043881
			6612ft.59	
258 33 32.85	78 34 22.15	City Line East	1798m.01	3.2547928
			5898ft.97	
328 27 33.82	148 28 00.61	Straus	1831m.81	3.2628800
			6009ft.86	
91 21 15.65	271 18 29.11	Highbridge	5967m.08	3.7757615
			19576ft.99	
196 52 20.05	16 52 53.49	Straus	4124m.32	3.6153522
			13531ft.21	
300 37 03.64	120 38 48.03	Jackson	4348m.20	3.6383099
			14265ft.72	
4 23 35.71	184 23 19.58	Jackson	7545m.48	3.8776866
			24755ft.46	
39 08 24.75	219 06 24.16	Protectory	6841m.83	3.8351721
			22446ft.90	
63 20 45.02	243 15 57.80	Highbridge	11506m.85	4.0609566
			37752ft.06	
66 26 10.54	246 24 43.35	Straus	3403m.12	3.5318778
			11165ft.07	
156 03 44.96	336 03 05.00	Morris High School	3530m.82	3.5478752
			11584ft.03	
206 02 44.03	26 03 24.91	Ludlow	3337m.83	3.5234637
			10950ft.86	
291 35 56.96	111 37 33.48	College Point schoolhouse	3725m.83	3.5712228
			12223ft.83	

BOROUGH OF
GEOGRAPHICAL

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
25	Rikers Island—*Continued.*				
26	Straus	40 52 36.643	1130^{m}.3 3708^{ft}.3	73 50 53.095	1243^{m}.2 4078^{ft}.7
27	Throgs Neck lighthouse (new)	40 48 17.546	541^{m}.2 1775^{ft}.6	73 47 35.058	821^{m}.8 2696^{ft}.2
28	Westchester court-house	40 50 33.070	1020^{m}.1 3346^{ft}.8	73 50 40.044	938^{m}.1 3077^{ft}.7
29	West Farms schoolhouse	40 50 26.864	828^{m}.6 2718^{ft}.5	73 52 57 760	1353^{m}.2 4439^{ft}.6

THE BRONX.

POSITIONS—*Continued.*

Azimuth.	Black Azimuth.	To Stations.	Distance.	Logarithms.
° ′ ″	° ′ ″			
73 50 17.11	253 47 33.44	Memorial church.....	6115^{m}.33	3.7864199
			20063^{ft}.38	
337 33 57.95	157 35 08 95	Jackson	6666^{m}.27	3.8238828
			21870^{ft}.92	
62 01 31.63	241 58 11.60	Highbridge	8110^{m}.75	3.9090612
			26610^{ft}.02	
349 03 38.90	169 03 56.82	Bayside.....	3389^{m}.33	3.5301137
			11119^{ft}.83	
44 37 39.66	224 36 42.59	Whitestone schoolhouse.	2915^{m}.60	3.4647273
			9565^{ft}.60	
105 07 56.15	285 05 49.48	Castle	4706^{m}.08	3.6726589
			15439^{ft}.86	
4 01 06.88	184 01 01.09	Castle	2960^{m}.71	3.4713962
			9713^{ft}.60	
48 07 55.20	228 06 54.66	Ludlow.....	2913^{m}.11	3.4643566
			9557^{ft}.43	
148 53 43.41	328 53 14.88	Parkway.....	1976^{m}.74	3.2959500
			6485^{ft}.35	
216 05 37.72	36 06 59.26	Straus.....	4954^{m}.99	3.6950426
			16256^{ft}.50	
229 28 34.92	49 29 36.47	Parkway	2899^{m}.93	3.4623882
			9514^{ft}.19	
268 06 38.64	88 07 26.73	Protectory.....	1723^{m}.85	3.2364995
			5655^{ft}.66	
328 53 35.15	148 54 04.66	Ludlow.....	2047^{m}.44	3.3112113
			6717^{ft}.31	
50 21 40.92	230 20 49.57	Morris High School....	2389^{m}.86	3.3783728
			7840^{ft}.74	

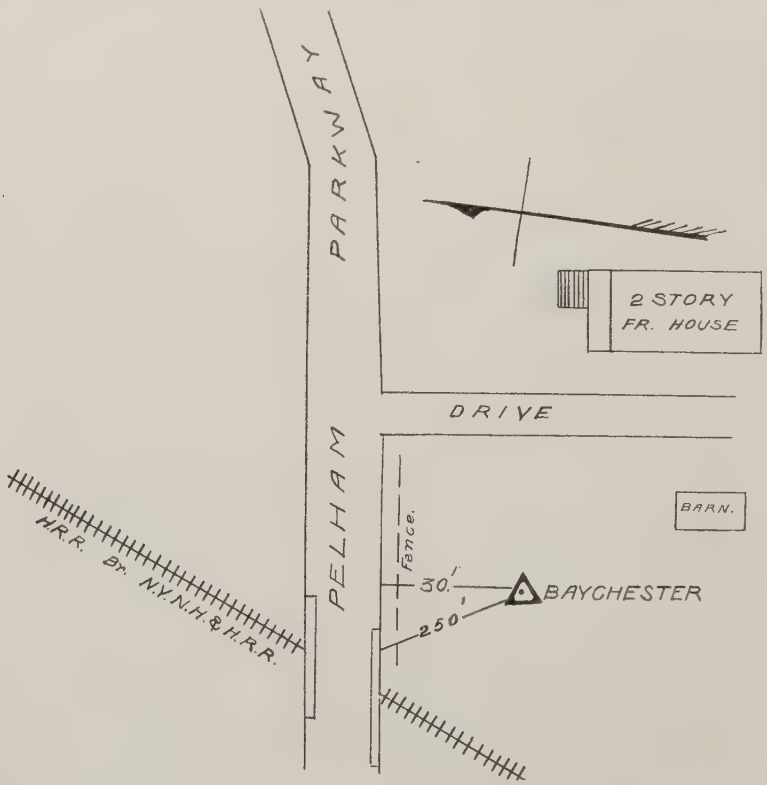
DESCRIPTION OF STATIONS—BOROUGH OF BRONX.

BAYCHESTER.

This station consists of an 84-foot tripod and scaffold and was built over a granite monument with a copper bolt in center, which marks the south end of the old Baychester Base line; the bolt has a deep cut in it running east and west, and the station when plumbed comes exactly in the center of the cut and bolt.

This station is just south of Pelham Parkway and east of the Harlem River Branch of the N. Y., N. H. & H. R. R. in the Town of Baychester, Westchester County, Borough of The Bronx, New York City, N. Y.

The station is reached by the Harlem Branch of the N. Y., N. H. & H. R. R. to Baychester and walking south to Pelham Parkway.



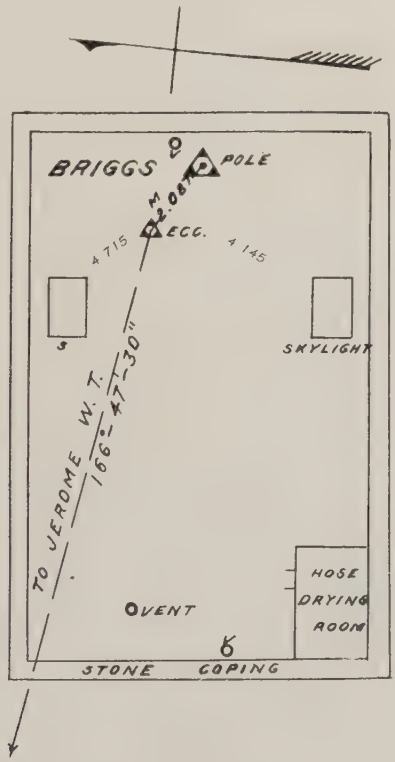
BRIGGS.

This station is the flagpole on the roof of Engine House No. 62, Williamsbridge, Borough of The Bronx, New York City, N. Y.

The building is built of brick with a flat rectangular tin roof.

An eccentric station was made west of the flagpole by placing a brass tack in the roof and referencing it to the pole and to the nearest edges of two skylights.

The station is reached by N. Y. C. R. R. to Williamsbridge station, thence along Gun Hill road to Olin avenue, thence south about 300 yards along Olin avenue to firehouse.

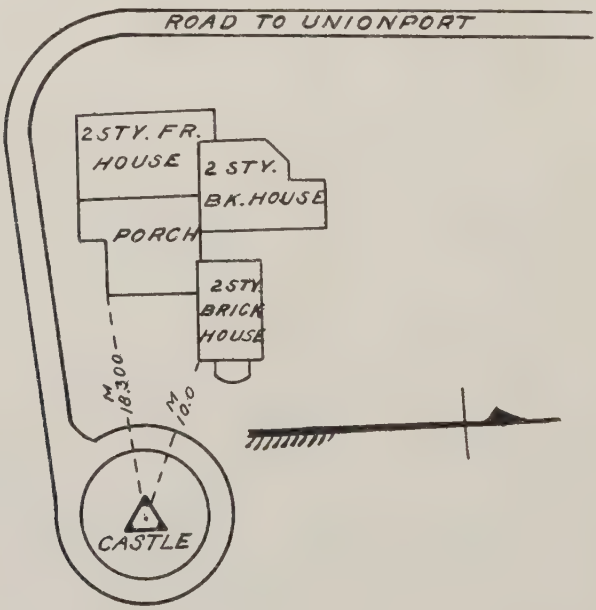


CASTLE.

Station Castle is situated on Castle Hill, in the grounds of John B. McDonald, just south of the Village of Unionport, Borough of The Bronx, New York City, N. Y.

The station consists of a 68-foot tripod and scaffold. It is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt.

Reached by electric car from Westchester Village to Unionport, getting off at Castle Hill avenue and walking south on Castle Hill avenue to its terminus, thence following wagon road to Castle Hill.

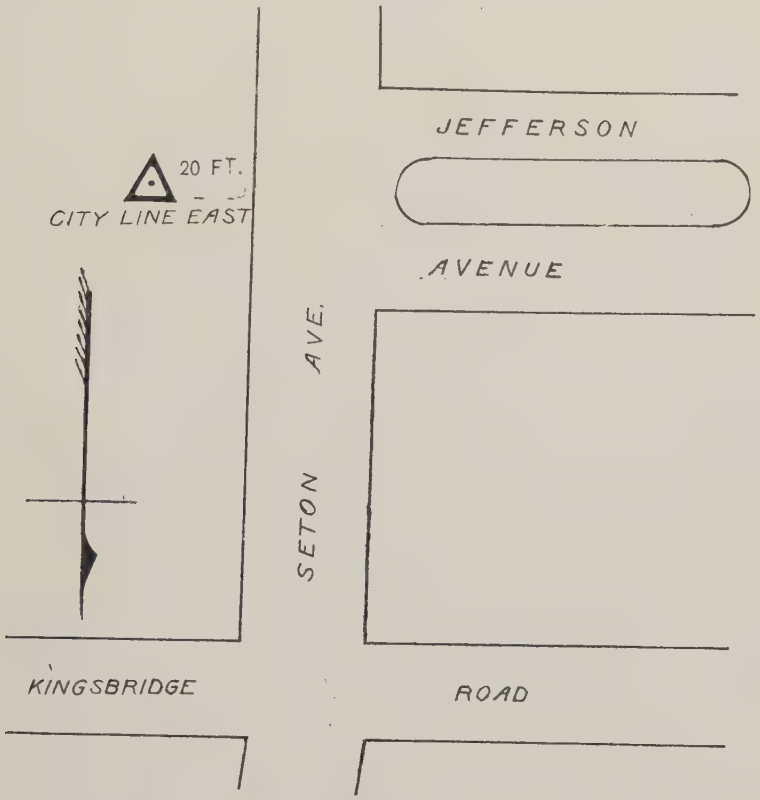


CITY LINE EAST.

Station City Line East is a 68-foot tripod and scaffold, situated on the northern boundary of the City of New York in Edenwald, just north of Wakefield.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A small hole drilled in top of bolt marks the center.

Reached by taking Fifth avenue electric car from Mount Vernon, getting off at Kingsbridge road, and walking west one-half mile.

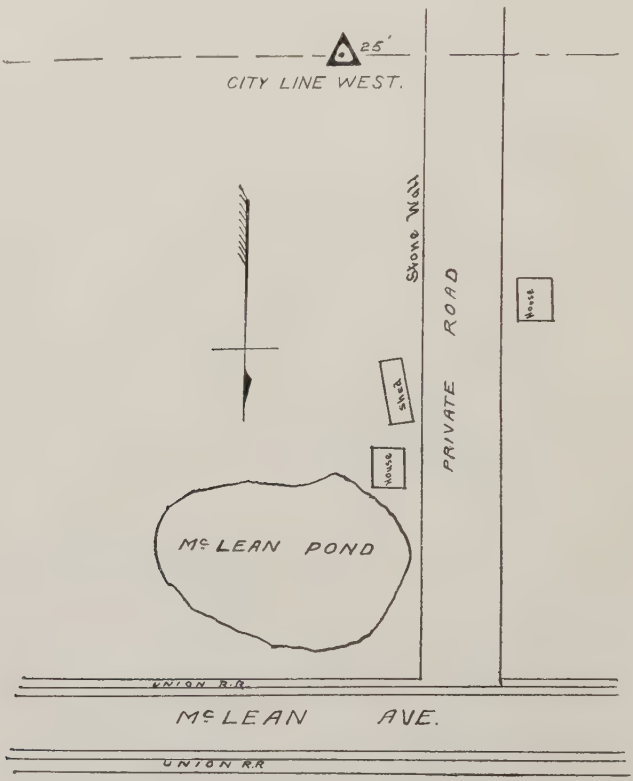


CITY LINE WEST.

This station consists of an 86-foot tripod and scaffold and was built over a marble monument marking the northern boundary of the City of New York. The center of the station was marked by a cross cut on the top of the monument. It is situated on the northern boundary of the City of New York, just west of Woodlawn and southwest of Mount Vernon.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by taking Yonkers electric car from Fordham, Mount Vernon or Yonkers, getting of at McLean Ice Pond at Mile Square and walking south one-quarter of a mile to station.

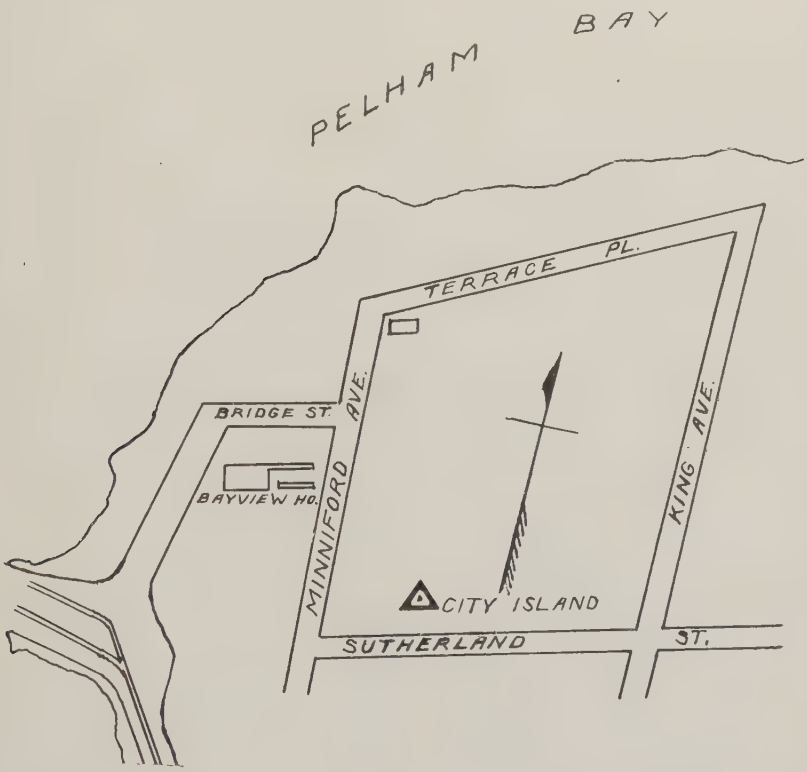


CITY ISLAND.

This station consists of a 52-foot tripod and scaffold, erected at the intersection of Minniford avenue and Sutherland street, City Island, Borough of The Bronx, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by N. Y., N. H. & H. R. R. to Bartow, thence by street railroad to Bridge street, thence to Minniford avenue and Sutherland street station.

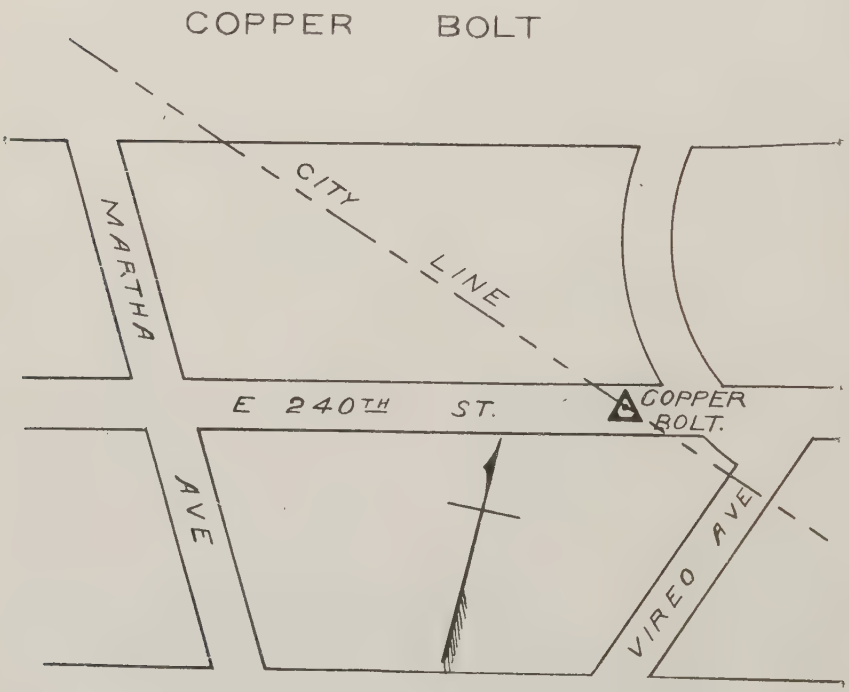


COPPER BOLT.

Station Copper Bolt is a punch mark in a copper bolt set in a marble monument which is, in turn, set in a bed of concrete at the intersection of the northern city boundary line and East Two Hundred and Fortieth street, Borough of The Bronx, New York City, N. Y.

During the work of triangulation the station was marked by a black and white pole set in a ten-foot tripod, but this has since been removed.

Reached by Third avenue elevated train to Bronx Park station, thence by McLean avenue trolley to Two Hundred and Fortieth street.



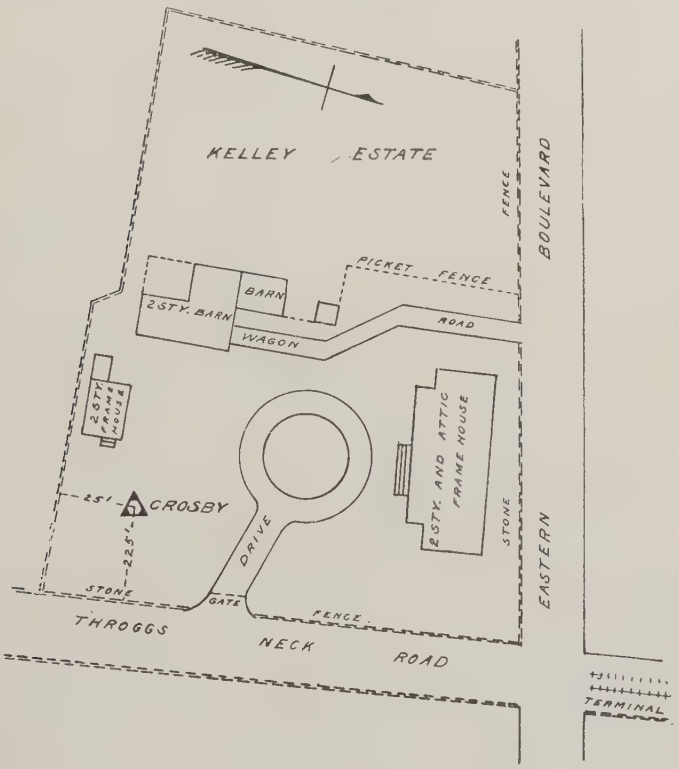
CROSBY.

Station Crosby is on Eastern Boulevard, about 100 yards south of its intersection with Throgs Neck road, in the grounds of Mr. Kelley on the south side of the Eastern Boulevard.

Station Crosby is the eastern end of the Unionport Base Line. A tripod and scaffold 68 feet high was erected over the old station of the Bronx triangulation.

The original block of stone set in concrete was about 4 feet under the surface. Mr. Holden, Assistant Engineer, of the Borough of The Bronx, put in above this underground mark a marble block 0′.65 x 0′.65 x 4′.00 set in concrete 3′ x 3′ x 4′. In the surface of this block nearly level with the surface of the ground was set a copper bolt ½ inch in diameter on which is cut a cross with a small hole in the intersection.

Crosby is reached by taking electric car from Westchester Village to Eastern Boulevard, which is the terminus of the railroad. The gate shown in sketch is about 600 feet distant.



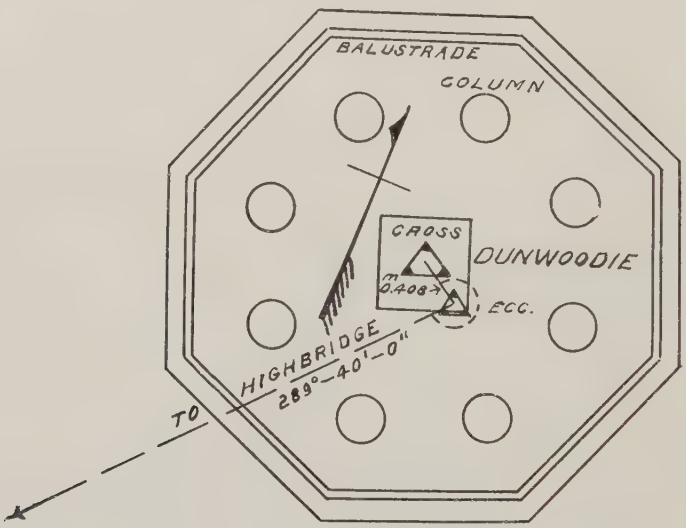
DUNWOODIE.

This station is the cross on the roof of the main cupola of St. Joseph's Seminary at Dunwoodie, Yonkers, N. Y.

The roof upon which cross is placed is supported by eight round columns having square bases. The point was reduced on the trap door to take observations. This was done by stretching strings from the centers of these columns and taking the intersections.

The line to Highbridge passes over large chimneys of power-house, making this line very difficult to get.

Reached by N. Y. C. R. R. to Yonkers or Mount Vernon, at Grand Central Depot, Forty-second street, New York City, thence by Yonkers avenue trolley to Seminary.

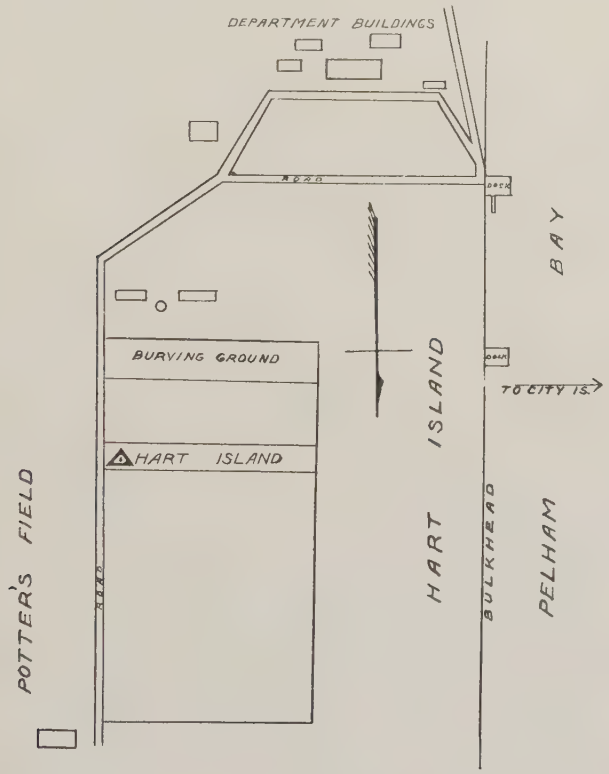


HART ISLAND.

This station consists of a 30-foot tripod and scaffold erected at about the center of Hart Island, Borough of The Bronx, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by N. Y., N. H. & H. R. R. to Bartow, thence by street railroad to Macedonia avenue; walk down Macedonia avenue to Smith's Hotel, and thence across Pelham Bay by boat to Hart Island.

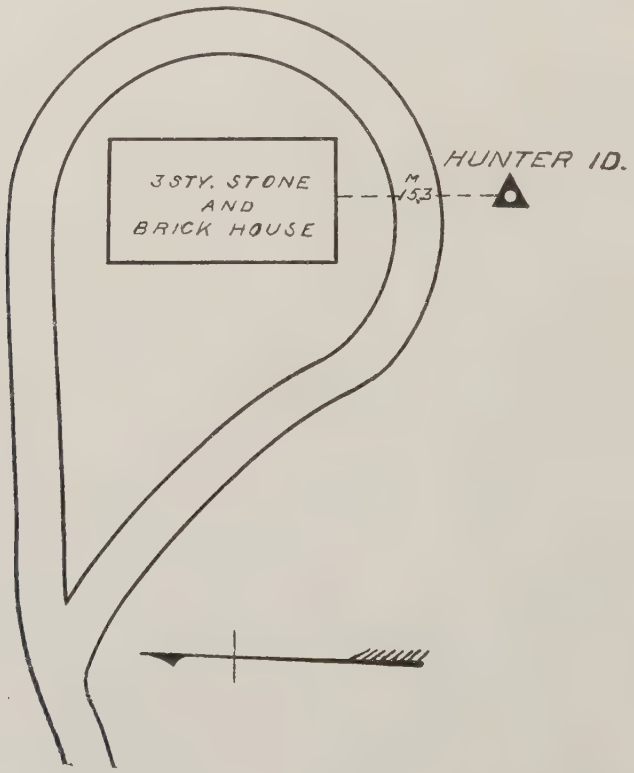


HUNTER ISLAND.

Station Hunter Island is in the center of Hunter Island, Pelham Bay, Borough of The Bronx, New York City, N. Y.

The station consists of an 84-foot tripod and scaffold. It is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ which is set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Hunter Island is reached by means of the Harlem River Branch of the N. Y., N. H. & H. R. R., getting off at Bartow and taking hack for Hunter Island.

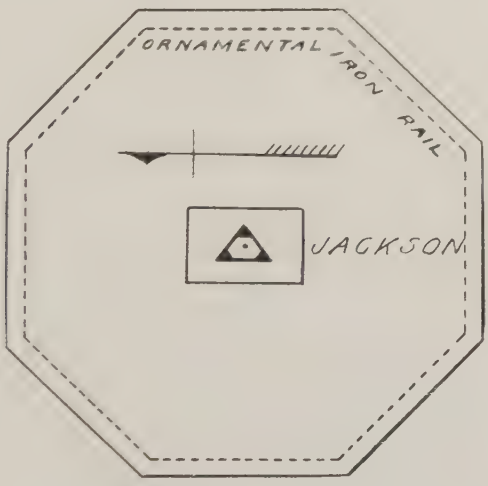


JACKSON.

This station is the water tower of Mr. F. W. Jackson on the Fort Schuyler road, Throgs Neck, about one mile southeast of Boulevard, Borough of The Bronx, New York City, New York.

The tower is octagonal in plan and is almost entirely of brick, the portion above tank being of wood and slightly tapered. This portion has a side covering of slate and a flat tin roof. Access to roof is by wooden ladder through a 2′.2 x 3′.2 scuttle in center of roof, which is surrounded by ornamental iron railing about 3 feet high.

The station is at the center of the tower on the trap door and is the point used in The Bronx triangulation on authority of Mr. E. Ankener.



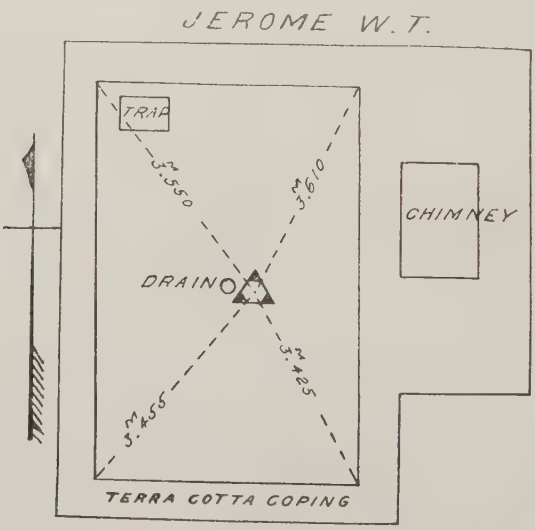
JEROME WATER TOWER.

This station is the tower of the Jerome Park reservoir pumping station, situated on Jerome and Van Courtlandt avenues, Borough of The Bronx, New York City, N. Y.

The station is reached by Third avenue elevated train to Tremont avenue station, thence by Sedgwick avenue trolley to Jerome avenue, then transferring to Jerome avenue trolley to station; or by Sixth or Ninth avenue elevated train to One Hundred and Fifty-fifth street station and transferring to Jerome avenue trolley.

The tower is wholly of brick, square in plan, with a terra cotta coping. The roof is flat with a tiled floor. Access to roof is gained by a narrow stairway through a trap door in roof.

The station is marked with a copper bolt set in the floor immediately east of a small drain which is the center of the tower.

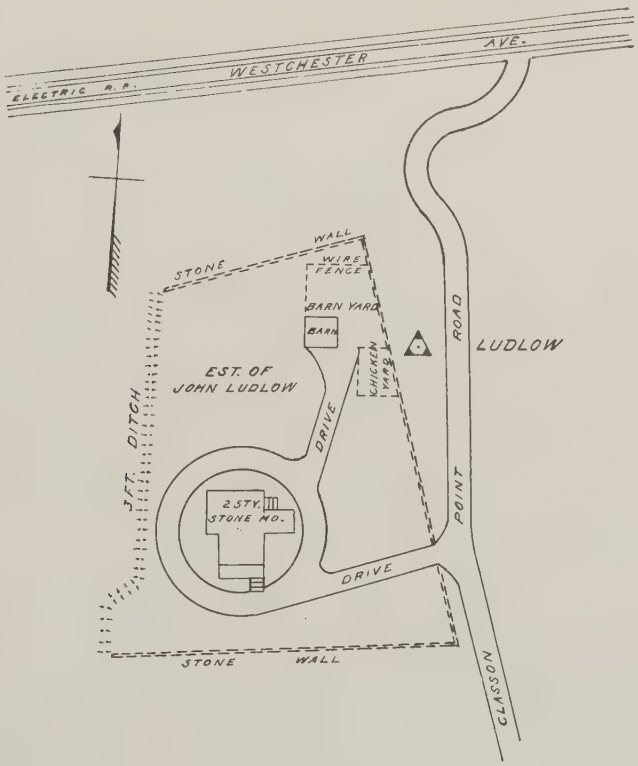


LUDLOW.

Station Ludlow is the west end of the Unionport Base Line and adjoins the estate of John Ludlow. It is 75 feet west of Classon point road and one-half mile south of Westchester avenue.

A tripod and scaffold 84 feet high was erected over the old station of The Bronx triangulation. The original block of stone set in concrete is about 4 feet below the surface of the adjoining ground and is marked by a copper bolt 1 inch in diameter, on which is cut a cross. The block is covered with an iron plate on which is inscribed "Triangulation Monument."

Ludlow is reached by taking electric car from Westchester Village to Classon Point road going through the Village of Unionport. Get off at Classon Point road to left and walk south about one-half mile.

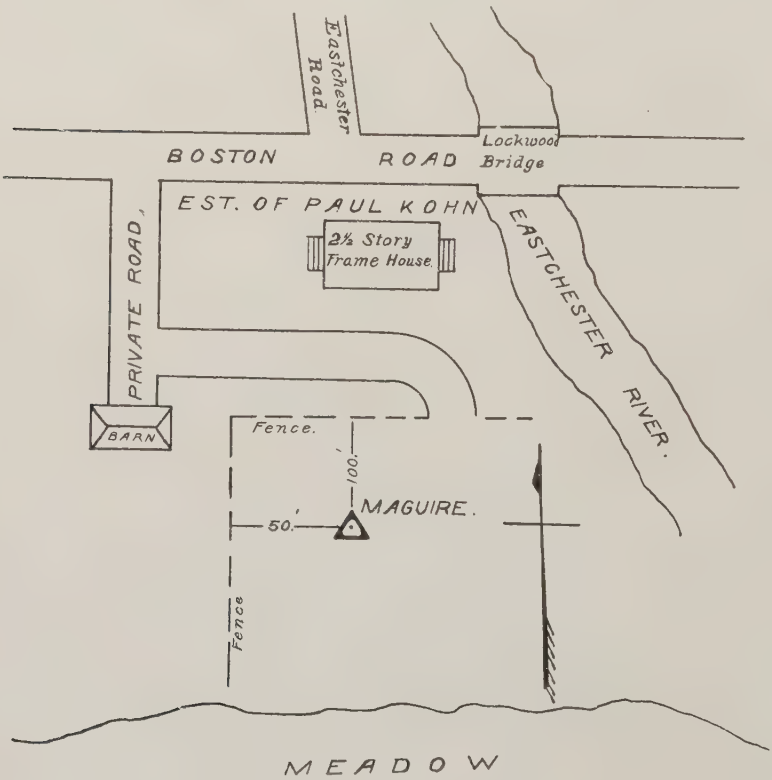


MAGUIRE.

This station consists of an 84-foot tripod and scaffold on the estate of Paul Kohn, just south of Boston road, in the Town of Eastchester, Westchester County, Borough of The Bronx, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by the N. Y., N. H. & H. R. R. to Bartow, and thence by carriage to Eastchester and station.

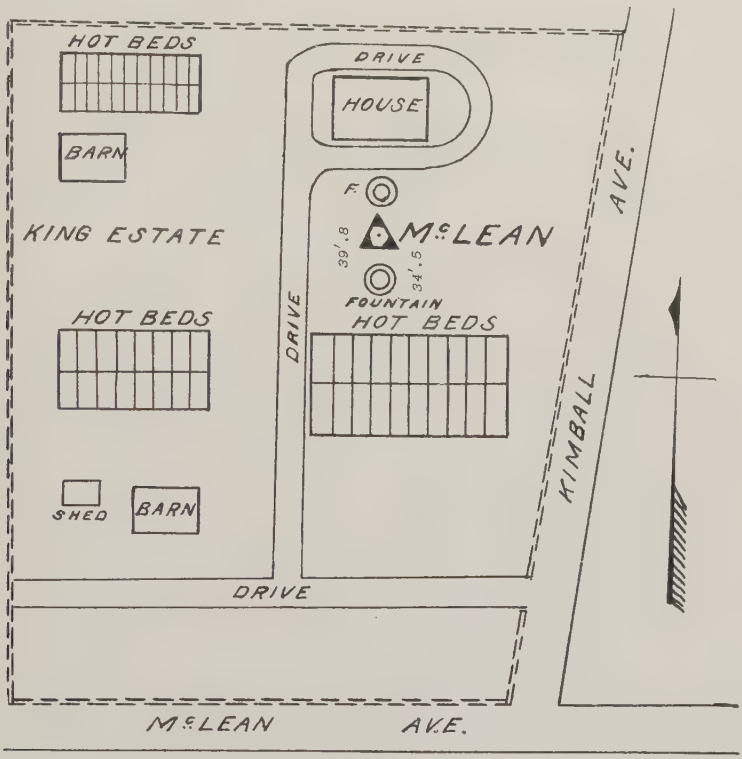


McLEAN.

This station is a 52-foot tripod and scaffold with a 4-inch white and black pole. It is situated on McLean Heights near Mount Vernon.

The station is reached by Third avenue elevated train to Bronx Park station, transferring there to Yonkers trolley, and getting off at McLean and Kimball avenues. Walk north 300 yards to tower.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.



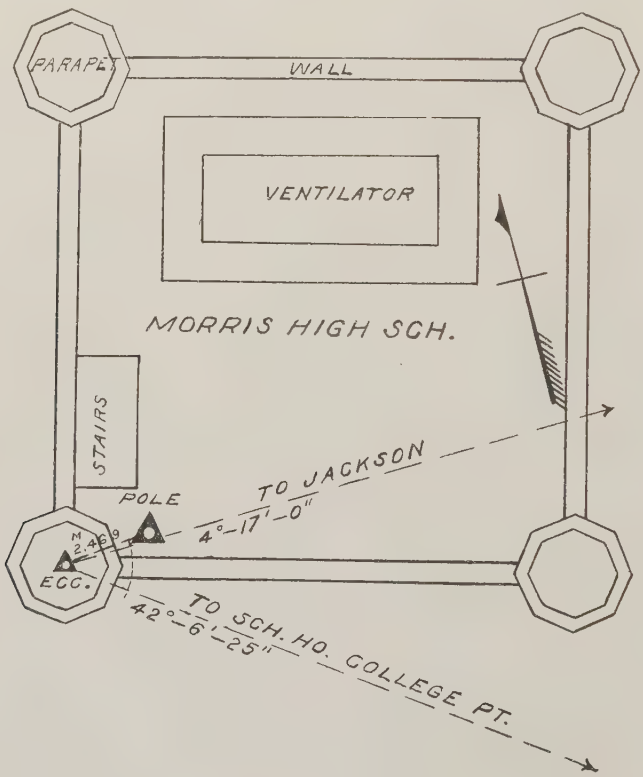
MORRIS HIGH SCHOOL.

This station is the flagpole located in the southwest corner of the parapet tower of Morris High School, One Hundred and Sixty-sixth street and Boston road, Borough of The Bronx, New York City, N. Y.

The tower is of brick, square in plan, surmounted by an ornamental coping of gray, vitrified cement, with a hollow octagonal turret about 30 feet high on each corner.

An eccentric station was made by erecting a tripod and scaffold in the southwest turret.

The station is reached by Third avenue elevated train to One Hundred and Sixty-sixth street station which is directly opposite the school

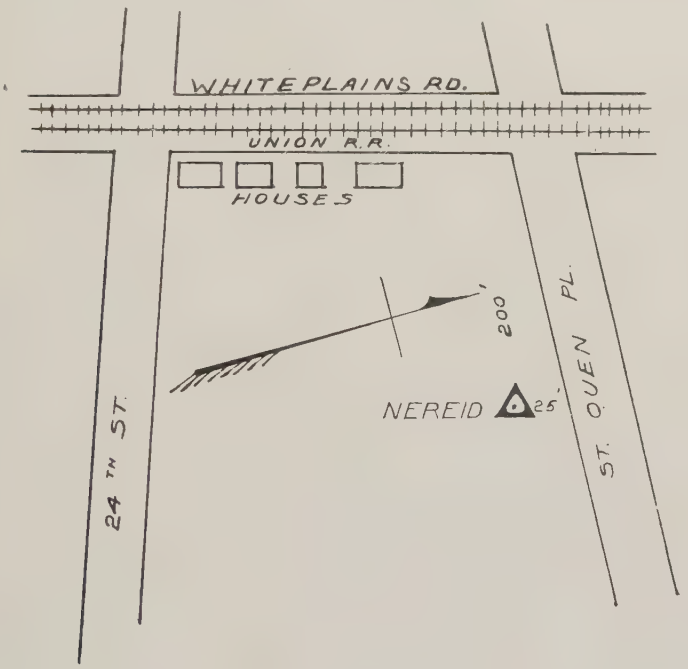


NEREID.

This station consists of an 84-foot tripod and scaffold near the intersection of St. Ouen place and White Plains road, Wakefield, Borough of The Bronx, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by N. Y. C. R. R. to Wakefield, or by the Third avenue elevated to Bronx Park and thence by Mount Vernon to St. Ouen place and station.



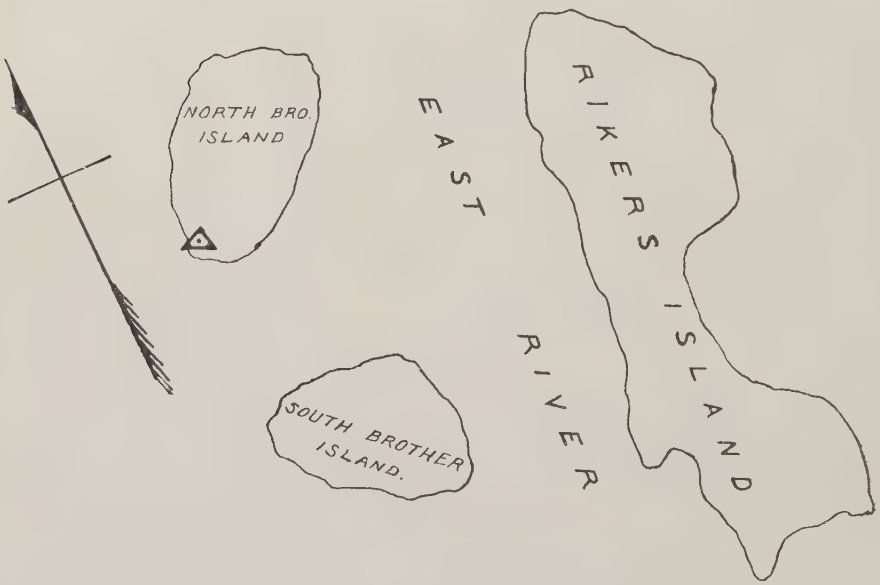
NORTH BROTHER ISLAND LIGHTHOUSE.

Station North Brother Island Lighthouse is the base of the rod on the lighthouse as described above, located on the southerly end of North Brother Island, East River, Borough of The Bronx, New York City, N. Y.

The lighthouse is white with black iron roof and yellow curtains. The light is a white flash light.

Reached by Third avenue elevated train to One Hundred and Thirty-eighth street station, thence by One Hundred and Thirty-eighth street surface to East River, thence by boat to station.

NORTH BROTHER ISD. L T. HO.

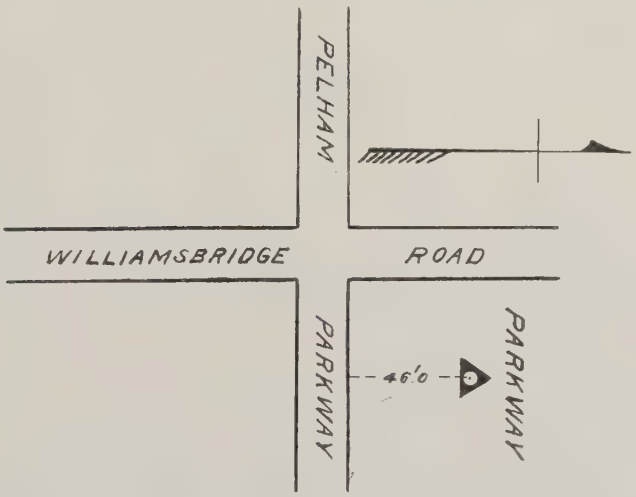


PARKWAY.

Station Parkway is situated on the northeast corner of Pelham Parkway and Williamsbridge road, Borough of The Bronx, New York City, N. Y.

The station consists of an 84-foot tripod and scaffold. It is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by Williamsbridge electric car from West Farms, or by taking hack from Westchester Village.

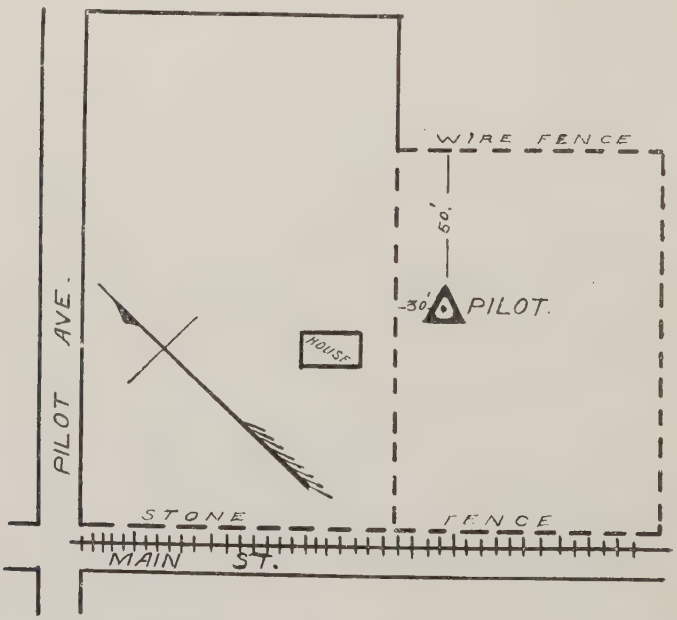


PILOT.

This station consists of a 52-foot tripod and scaffold erected in a vacant lot, near the intersection of Pilot avenue and Main street and opposite Ratsby & Lapthorne's sailmaking establishment, City Island, Borough of The Bronx, New York City, N. Y.

This station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by N. Y., N. H. & H. R. R. to Bartow, thence by street railroad to Pilot avenue.

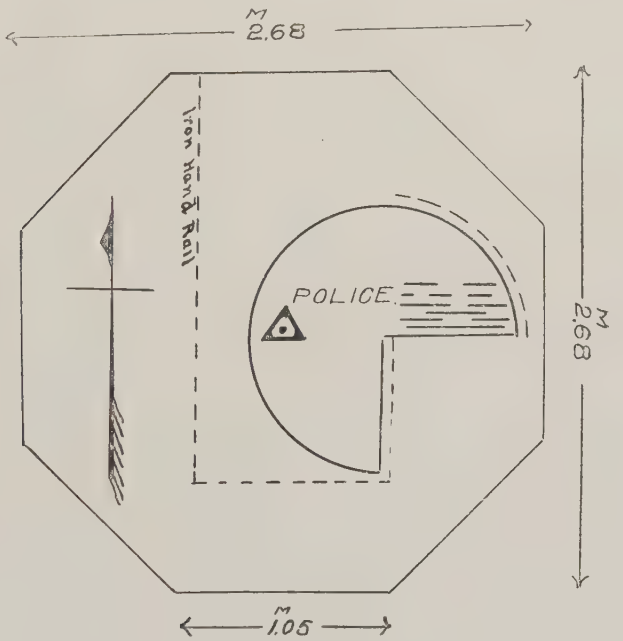


POLICE.

This station is the flagpole on the police station of the Thirty-ninth Precinct, corner Two Hundred and Twenty-ninth street and White Plains avenue, Wakefield, Borough of The Bronx, New York City, N. Y.

The station was reduced to a plank laid across the opening of the stairways in the octagonal dome of the building, and all angles taken from this point, and one eccentric.

The station is reached by N. Y. C. R. R. to Woodlawn station, walking east to White Plains avenue, thence down to Two Hundred and Twenty-ninth street; or by Third avenue elevated train to Bronx Park and Mount Vernon car to Two Hundred and Twenty-ninth street and White Plains avenue and station.



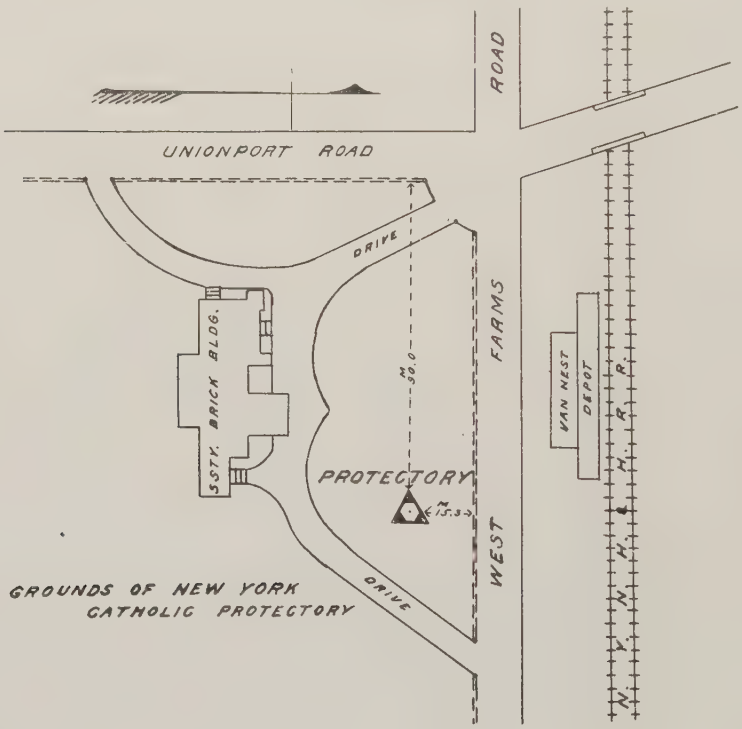
PROTECTORY.

Station Protectory is in the grounds of the New York Catholic Protectory, which are on the northeast corner of West Farms and Unionport roads, Borough of The Bronx, New York City, N. Y.

The station consists of an 84-foot tripod and scaffold on the lawn in front of the main building, and is 15.3 meters south of West Farms road, and 90 meters north of Unionport road.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

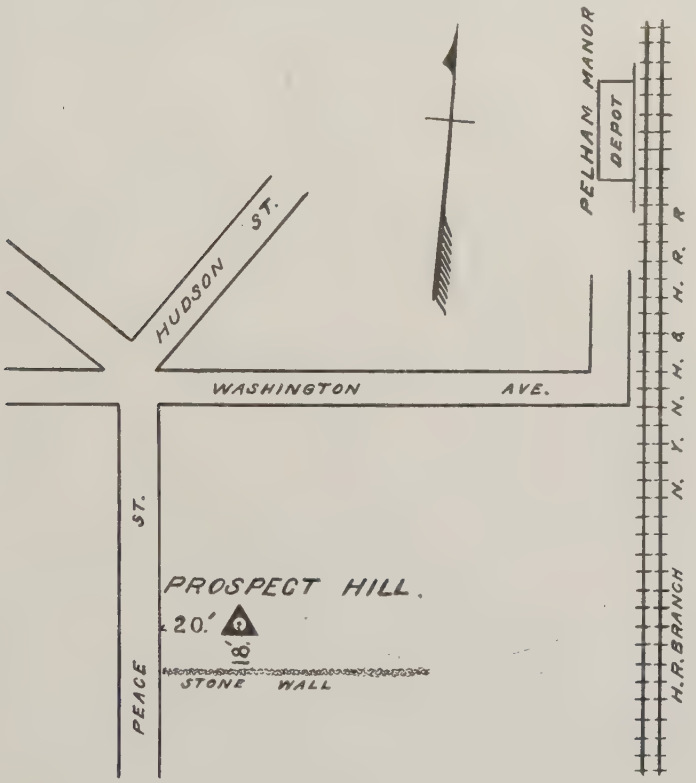
Protectory is reached by Westchester electric car from Tremont or West Farms, getting off at Unionport.



PROSPECT HILL.

Station Prospect Hill is situated in Pelham Manor, Town of Pelham, Westchester County, New York.

The station consists of a 68-foot tripod and scaffold. It is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

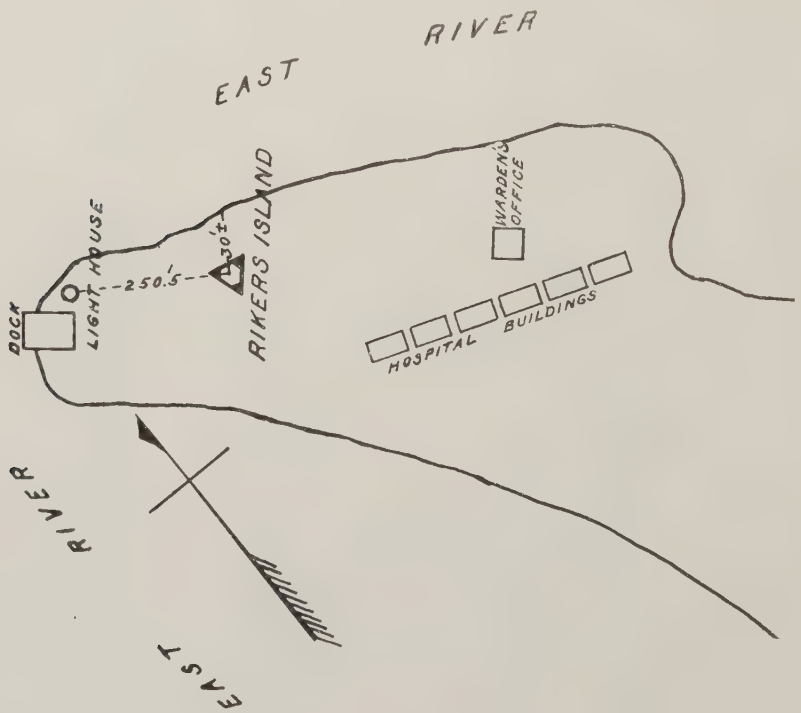


RIKERS ISLAND.

This station is on the northern shore of Rikers Island, about 30 feet from river and 250 feet east of Rikers Island Lighthouse.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt.

Reached by Third avenue elevated train to One Hundred and Thirty-eighth street station, thence by crosstown car to dock at foot of One Hundred and Thirty-eighth street, thence by boat to Rikers Island.

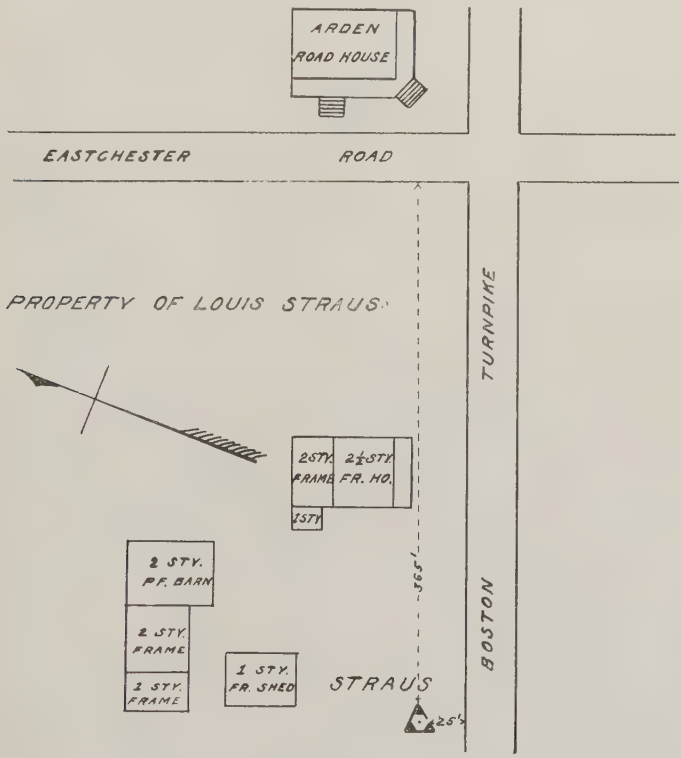


STRAUS.

Station Straus is situated in Williamsbridge, Borough of the Bronx, New York City, N. Y.

The station consists of an 86-foot tripod and scaffold. It is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by taking trolley to Williamsbridge to Eleventh street, thence taking hack to Eastchester road and Boston turnpike; or by taking N. Y. C. R. R. to Williamsbridge and taking hack to Straus.

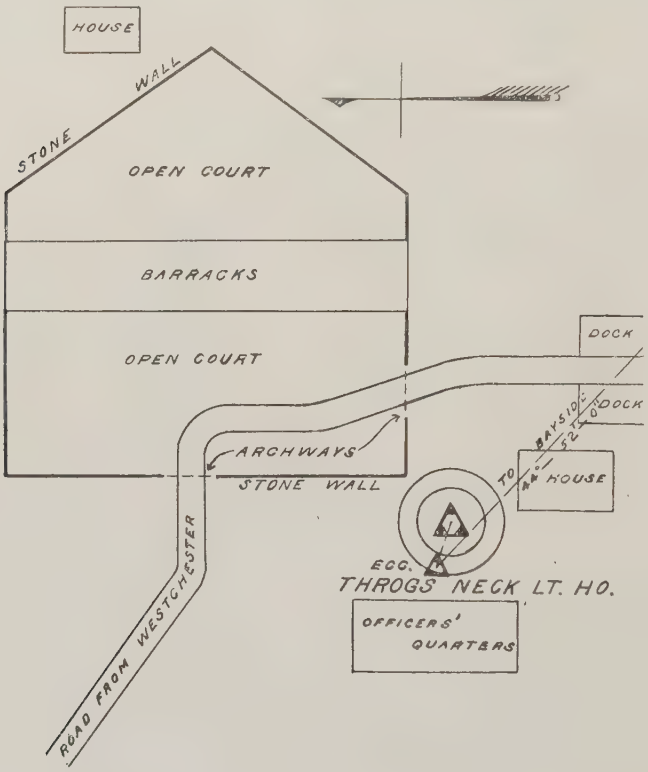


THROGS NECK LIGHTHOUSE.

This station is the center of the new lighthouse at the southeasterly end of Throgs Neck, Borough of The Bronx, New York City, N. Y.

This lighthouse is of the fourth order, is of brick and iron and 65 feet ± above the water. It has been in operation since July 25, 1906, being built to take the place of the old lighthouse which was torn down.

Reached by carriage from Westchester Village, Borough of The Bronx.

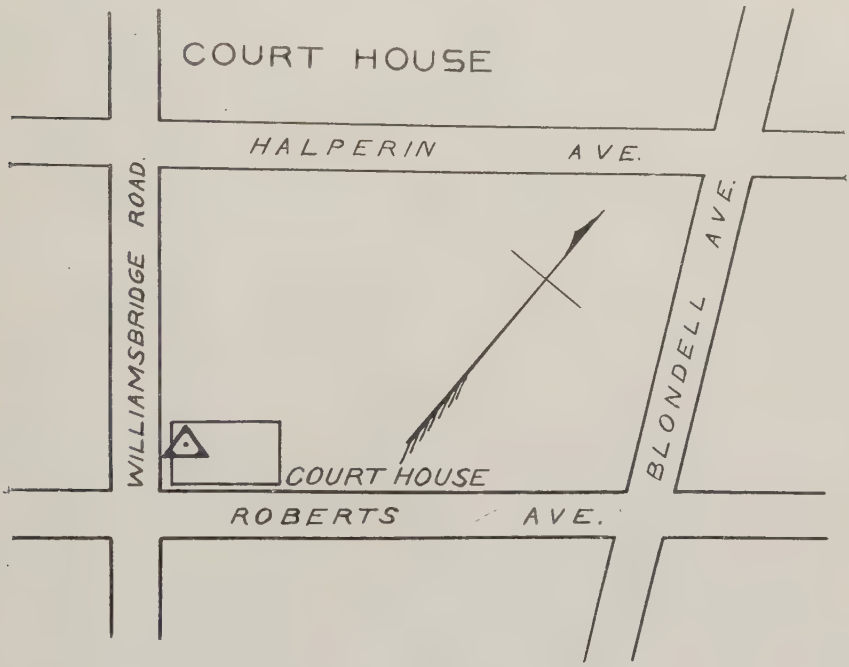


WESTCHESTER COURTHOUSE.

Station Westchester Courthouse is the base of the flagpole on the cupola of the County Courthouse, Williamsbridge road and Roberts avenue, Village of Westchester, Borough of The Bronx, New York City, N. Y.

The building is of stone. The cupola is square with flat roof. The pole leans to the east.

Reached by N. Y., N. H. & H. R. R. to Westchester.

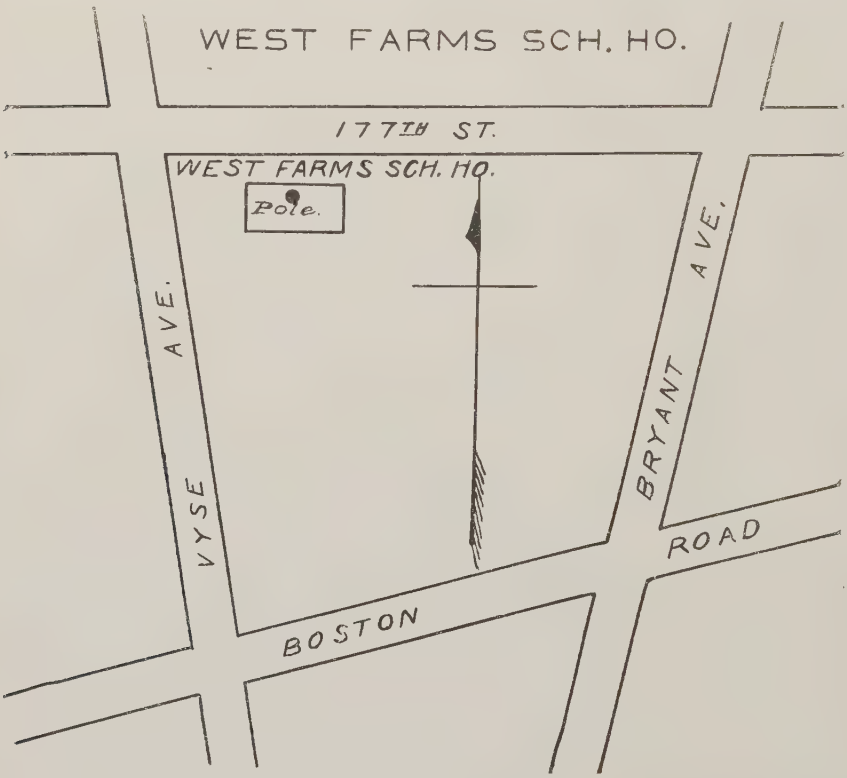


WEST FARMS SCHOOLHOUSE.

Station West Farms Schoolhouse is the base of the flagpole on Public School No. 6, One Hundred and Seventy-seventh street and Bryant avenue, West Farms, Borough of The Bronx, New York City, N. Y.

The building is practically rectangular in plan, three stories high, with flat tar and gravel roof. The pole is painted white.

Reached by West Farms subway to West Farms station.



Borough of Richmond.

BOROUGH OF RICHMOND.

RECTANGULAR CO-ORDINATES.

Bogart=Origin of Axes. True Meridian at Bogart=Axis of Ordinates.

No.	Station.	X in Meters.	X in Feet.	Y in Meters.	Y in Feet.
1	Asbury church	+ 4015.612	+ 13174.553	— 281.475	— 923.473
2	Bard	— 682.770	— 2240.055	+ 2314.149	+ 7592.337
3	Barclay	+ 4461.729	+ 14638.189	— 8433.871	— 27670.125
*	Bergen Point lighthouse	+ 2734.755	+ 8972.275	+ 4534.416	+ 14876.663
4	Bloomfield church	+ 6088.067	+ 19973.935	+ 1407.568	+ 4617.997
5	Bogart	0.0	0.0	0.0	0.0
6	Boundary beacon	+ 9293.567	+ 30490.644	— 13936.113	— 45722.064
7	Cromwell	— 858.090	— 2815.250	— 1053.649	— 3456.847
8	Dupuy	+ 4500.601	+ 14765.721	— 1723.003	— 5652.887
9	Elm tree	— 1715.572	— 5628.506	— 4236.677	— 13899.831
10	Fort Tompkins 2	— 5044.930	— 16551.574	+ 255.180	+ 837.203
11	Fox Hills	— 3582.706	— 11754.261	+ 672.462	+ 2206.236
12	Gifford	+ 3316.450	+ 10880.719	— 5357.376	— 17576.658
13	Great Beds lighthouse	+ 11641.162	+ 38192.712	— 12813.558	— 42039.148

* Bergen Point lighthouse is outside of the borough limits, but is included as part of the triangulation of Richmond Borough.

BOROUGH OF RICHMOND.

RECTANGULAR CO-ORDINATES—*Continued.*

Bogart=Origin of Axes. True Meridian at Bogart=Axis of Ordinates.

No.	Station.	X in Meters.	X in Feet.	Y in Meters.	Y in Feet.
14	Great Kills	+ 1313.422	+ 4309.119	— 7351.519	— 24119.109
15	Huguenot church	+ 6567.224	+ 21545.967	— 7835.990	— 25708.577
16	Jessup	+ 6230.273	+ 20440.487	— 5990.575	— 19654.078
17	Kendall	— 2217.073	— 7273.847	+ 2210.799	+ 7253.263
18	Kreusler	+ 10058.515	+ 33000.311	— 7795.136	— 25574.542
19	Kolff	— 1683.479	— 5523.214	+ 477.831	+ 1567.684
20	Lambert	+ 4086.287	+ 13406.426	+ 1576.271	+ 5171.483
21	Linoleumville schoolhouse	+ 6310.465	+ 20703.584	— 1157.406	— 3797.256
22	Northeast base	— 1684.476	— 5526.485	— 1997.284	— 6552.756
23	New Creek	— 3287.016	— 10784.152	— 2414.219	— 7920.650
24	Old Orchard lighthouse	— 1442.551	— 4732.760	— 9975.257	— 32727.158
25	Old Place	+ 6145.680	+ 20162.952	+ 3321.048	+ 10895.805
26	Princess Bay lighthouse	+ 8277.607	+ 27157.449	— 10484.870	— 34399.111
27	Quarry Hill schoolhouse	+ 2475.897	+ 8123.005	+ 3218.117	+ 10558.105
28	Rossville	+ 8700.250	+ 28544.070	— 6412.163	— 21037.238

29	St. George schoolhouse	— 2898.850	— 9510.644	+ 4789.865	+ 15714.749
30	St. Michaels	+ 5862.720	+ 19234.607	— 4521,930	— 14835.699
31	Sharrot	+ 8401.452	+ 27563.763	— 8467.637	— 27780.905
32	Snug Harbor church	— 1261.081	— 4137.397	+ 4594.922	+ 15075.173
33	Stapleton schoolhouse	— 3214.745	— 10547.042	+ 2584.799	+ 8480.295
34	Summerfield church	+ 3783.408	+ 12412.731	+ 3569. 087	+ 11709.580
35	S. S. White	+ 6816.022	+ 22362.232	— 10063.380	— 33016.272
36	Southwest base	+ 169.697	+ 556.748	— 4378.486	— 14365.115
37	Tottenville schoolhouse	+ 10833.269	+ 35542.150	— 10380.552	— 34056.861
38	Westerleigh schoolhouse	+ 1466.564	+ 4811.552	+ 1810.614	+ 5940.323
39	West Brighton schoolhouse	+ 112.938	+ 370.531	+ 3727.314	+ 12228.696
40	Wyeth	+ 1498.035	+ 4914.803	— 2488.567	— 8164.573

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
1	Asbury church.....	40	35	58.489	$1804^{m}.1$	74	09	48.800	$1147^{m}.4$
					$5919^{ft}.0$				$3764^{ft}.4$
2	Bard.....	40	37	22.672	$699^{m}.3$	74	06	28.964	$680^{m}.8$
					$2294^{ft}.3$				$2233^{ft}.6$
3	Barclay.....	40	31	34.183	$1054^{m}.4$	74	10	07.567	$178^{m}.1$
					$3459^{ft}.3$				$584^{ft}.3$
*	Bergen Point light-house.....	40	38	34.636	$1068^{m}.3$	74	08	54.400	$1278^{m}.2$
					$3504^{ft}.9$				$4193^{ft}.6$

*This station is not in Richmond Borough, but is included as part of the Richmond triangulation.

RICHMOND.

POSITIONS.

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
69	04	39.39	249	03	35.88	Linoleumville schoolhouse	2456^{m}.34	3.3902884
							8058^{ft}.84	
129	08	56.50	309	07	59.09	Bloomfield church	2673^{m}.56	3.4270905
							8771^{ft}.52	
183	25	12.33	3	25	18.70	Summerfield church	3857^{m}.56	3.5863125
							12656^{ft}.01	
265	57	34.29	85	59	25.43	Bogart	4025^{m}.46	3.6048160
							13206^{ft}.88	
16	26	36.62	196	26	17.71	Bogart	2412^{m}.77	3.3825160
							7915^{ft}.90	
63	36	16.97	243	33	03.39	Linoleumville schoolhouse	7807^{m}.50	3.8925120
							25615^{ft}.11	
105	58	32.34	285	57	04.83	Quarry Hill schoolhouse.	3285^{m}.47	3.5165981
							10779^{ft}.09	
150	37	21.87	330	36	59.83	West Brighton schoolhouse	1621^{m}.78	3.2099931
							5320^{ft}.80	
273	51	32.12	93	52	14.62	Kendall	1537^{m}.78	3.1868941
							5045^{ft}.20	
144	04	02.62	324	03	13.73	Jessup	3016^{m}.20	3.4794597
							9895^{ft}.64	
235	46	17.22	55	49	07.83	Elm Tree	7468^{m}.29	3.8732215
							24502^{ft}.24	
250	59	36.22	71	01	03.14	Great Kills	3329^{m}.16	3.5223349
							10922^{ft}.43	
328	53	03.54	148	54	19.32	Bogart	5295^{m}.26	3.7238875
							17372^{ft}.87	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
*	Bergen Point lighthouse—*Continued.*				
4	Bloomfield church.....	40 36 53.201	1641^{m}.0 5383^{ft}.8	74 11 17.002	399^{m}.7 1311^{ft}.3
5	Bogart.....	40 36 07.650	236^{m}.0 774^{ft}.3	74 06 58.013	1364^{m}.0 4475^{ft}.1
6	Boundary beacon.....	40 28 35.656	1099^{m}.8 3608^{ft}.3	74 13 32.553	766^{m}.8 2515^{ft}.7

* This station is not in Richmond Borough, but is included as part of the Richmond triangulation.

RICHMOND.

POSITIONS – *Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
348 51 12.24	168 51 19.43	Quarry Hill schoolhouse.	1341^{m}.51	3.1275934
			4401^{ft}.27	
47 20 53.43	227 20 24.37	Summerfield church....	1425^{m}.32	3.1539118
			4676^{ft}.23	
4 54 31.17	184 54 25.06	Linoleumville schoolhouse.....	2574^{m}.60	3.4107092
			8446^{ft}.82	
178 13 44.19	358 13 42.55	Old Place.....	1914^{m}.35	3.2820209
			6280^{ft}.66	
226 47 19.88	46 48 23.68	Summerfield church....	3159^{m}.69	3.4996440
			10366^{ft}.41	
282 58 16.64	103 01 05.21	Bogart.....	6248^{m}.66	3.7957871
			20500^{ft}.82	
238 04 30.41	58 10 18.30	Prospect water tower...	14781^{m}.90	4.1697303
			48496^{ft}.96	
267 06 15.71	87 08 35.36	Fort Tompkins 2.....	5051^{m}.38	3.7034100
			16572^{ft}.74	
284 22 39.31	104 28 08.84	Centennial tower.....	12298^{m}.46	4.0898507
			40349^{ft}.20	
328 15 05.31	148 19 31.31	Sandy Hook lighthouse.	18328^{m}.13	4.2631179
			60131^{ft}.51	
156 30 51.01	336 30 08.42	Tottenville schoolhouse.	3874^{m}.62	3.5882292
			12711^{ft}.99	
172 49 41.81	352 49 20.47	Kreusler.....	6188^{m}.44	3.7915809
			20303^{ft}.23	
196 19 54.67	16 20 22.57	Princess Bay lighthouse.	3597^{m}.67	3.5560215
			11803^{ft}.36	

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
7	Cromwell	40	35	33.489	1033^{m}.0	74	06	21.521	506^{m}.1
					3389^{ft}.1				1659^{ft}.8
8	Dupuy	40	35	11.747	362^{m}.3	74	10	09.390	220^{m}.8
					1188^{ft}.6				724^{ft}.4
9	Elm Tree	40	33	50.292	1551^{m}.3	74	05	45.087	1060^{m}.7
					5089^{ft}.6				3480^{ft}.0
10	Fort Tompkins 2	40	36	15.867	489^{m}.4	74	03	23.433	551^{m}.0
					1605^{ft}.6				1807^{ft}.7
11	Fox Hills	40	36	29.422	907^{m}.5	74	04	25.618	602^{m}.2
					2977^{ft}.4				1975^{ft}.7

RICHMOND.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
299 15 43.49	119 16 50.68	New Creek	2784m.03	3.4446742
			9133ft.94	
318 47 47.04	138 48 09.91	Northeast Base	1254m.34	3.0984140
			4115ft.27	
344 55 46.20	164 56 09.90	Elm Tree	3296m.51	3.5180538
			10815ft.29	
140 50 50.24	320 50 26.50	Bogart	1358m.86	3.1331740
			4458ft.19	
107 19 11.54	287 18 21.43	Linoleumville schoolhouse	1896m.18	3.2778800
			6221ft.06	
198 33 37.72	18 33 51.12	Asbury church	1520m.93	3.1821082
			4989ft.91	
249 00 59.90	69 03 04.43	Bogart	4819m.14	3.6829699
			15810ft.81	
44 12 45.41	224 11 21.74	Great Kills	4344m.77	3.6379669
			14254ft.47	
118 33 29.14	298 32 00.29	Wyeth	3658m.30	3.5632793
			12002ft.27	
157 58 06.64	337 57 19.20	Bogart	4570m.85	3.6599965
			14996ft.18	
216 33 32.24	36 35 04.41	Fort Tompkins 2	5591m.19	3.7475043
			18343ft.77	
285 57 17.49	105 57 57.96	Fort Tompkins 2	1520m.60	3.1820146
			4988ft.83	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
11	Fox Hills—*Continued.*				
12	Giffords	40 33 13.943	430^{m}.1 1411^{ft}.1	74 09 18.969	446^{m}.3 1464^{ft}.2
13	Great Beds light-house	40 29 11.943	368^{m}.4 1208^{ft}.7	74 15 12.290	289^{m}.4 949^{ft}.5
14	Great Kills	40 32 09.312	287^{m}.2 942^{ft}.3	74 07 53.821	1266^{m}.7 4155^{ft}.8

RICHMOND.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
20 51 04.59	200 50 12.88	Elm Tree	5252m.22	3.7203430
			17231ft.66	
57 40 20.26	237 39 04.83	Cromwell	3225m.37	3.5085791
			10581ft.89	
84 10 34.89	264 09 42.31	Kolff	1909m.17	3.2808453
			6263ft.68	
77 42 51.41	257 41 30.92	Jessup	2981m.83	3.4744827
			9782ft.88	
108 08 22.21	288 07 11.83	St. Michaels	2679m.82	3.4281064
			8792ft.06	
144 29 26.76	324 28 03.90	Linoleumville schoolhouse	5157m.89	3.7124724
			16922ft.19	
212 20 36.15	32 21 26.40	Wyeth	3396m.57	3.5310408
			11143ft.59	
314 50 49.91	134 51 45.27	Great Kills	2826m.43	3.4512386
			9273ft.05	
198 16 47.15	18 17 09.33	Tottenville schoolhouse	2563m.63	3.4088557
			8410ft.85	
235 12 53.11	55 14 25.78	Princess Bay lighthouse	4091m.00	3.6118294
			13421ft.89	
295 27 59.61	115 29 04.36	Boundary beacon	2602m.18	3.4153368
			8537ft.31	
190 07 10.21	10 07 46.50	Bogart	7467m.93	3.8732000
			24501ft.02	
219 52 54.41	39 55 50.26	Fort Tompkins 2	9914m.16	3.9962558
			32526ft.70	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
14	Great Kills—*Continued.*				
15	Huguenot church.....	40 31 53.516	1650^{m}.7 5415^{ft}.7	74 11 37.040	871^{m}.8 2860^{ft}.2
16	Jessup.....	40 32 53.353	1645^{m}.7 5399^{ft}.3	74 11 22.789	536^{m}.2 1759^{ft}.2
17	Kendall.....	40 37 19.312	595^{m}.7 1954^{ft}.4	74 05 23.688	556^{m}.8 1826^{ft}.8

RICHMOND.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
251	59	22.95	72	05	28.55	Centennial tower	13907^{m}.39	4.1432456
							45627^{ft}.83	
306	54	47.38	126	59	49.44	Sandy Hook lighthouse	13706^{m}.48	4.1369260
							44968^{ft}.69	
32	47	59.79	212	47	12.66	Princess Bay lighthouse	3153^{m}.09	3.4987365
							10344^{ft}.77	
70	56	51.27	250	56	00.65	Sharrot	1939^{m}.94	3.2877883
							6364^{ft}.62	
190	17	49.66	10	17	58.92	Jessup	1875^{m}.92	3.2732153
							6154^{ft}.60	
285	48	07.68	105	49	05.81	Barclay	2188^{m}.74	3.3401936
							7180^{ft}.89	
194	18	33.10	14	19	40.62	Summerfield church	9867^{m}.84	3.9942222
							32374^{ft}.75	
226	04	32.91	46	07	25.13	Bogart	8643^{m}.11	3.9366699
							28356^{ft}.59	
260	45	28.73	80	53	50.26	Centennial tower	18379^{m}.68	4.2643380
							60300^{ft}.68	
285	25	25.81	105	27	41.64	Great Kills	5101^{m}.72	3.7077169
							16737^{ft}.90	
301	06	08.86	121	13	26.69	Sandy Hook lighthouse	18548^{m}.86	4.2683173
							60855^{ft}.73	
45	05	53.70	225	04	52.30	Bogart	3130^{m}.98	3.4956806
							10272^{ft}.23	
102	46	18.41	282	43	32.16	Summerfield church	6152^{m}.29	3.7890371
							20184^{ft}.65	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
17	Kendall—*Continued.*				
18	Kreusler.....	40 31 54.714	1687^{m}.7 5537^{ft}.1	74 14 05.379	126^{m}.6 415^{ft}.4
19	Kolff.....	40 36 23.134	713^{m}.6 2341^{ft}.2	74 05 46.405	1091^{m}.0 3579^{ft}.4

RICHMOND.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
189 04 27.36	9 05 19.06	Bergen Dutch Reformed church	11802^{m}.05	4.0719576
			38720^{ft}.58	
214 51 15.72	34 54 27.58	Park Row building	12092^{m}.54	4.0825175
			39673^{ft}.61	
241 31 35.10	61 36 21.62	Prospect water tower	11752^{m}.20	4.0701190
			38557^{ft}.00	
286 26 55.82	106 29 08.91	Fort Hamilton flag staff	5011^{m}.29	3.6999495
			16441^{ft}.21	
304 40 59.02	124 42 17.30	Fort Tompkins 2	3438^{m}.20	3.5363310
			11280^{ft}.16	
224 24 23.37	44 25 00.83	Rossville	1938^{m}.43	3.2874497
			6359^{ft}.66	
244 41 04.23	64 42 49.91	Jessup	4232^{m}.24	3.6265706
			13885^{ft}.28	
292 00 43.35	112 01 29.12	Sharrot	1788^{m}.33	3.2524475
			5867^{ft}.21	
326 24 49.52	146 25 38.77	Princess Bay lighthouse	3225^{m}.88	3.5086483
			10583^{ft}.58	
16 36 15.61	196 35 54.33	Tottenville schoolhouse	2699^{m}.00	3.4312034
			8854^{ft}.98	
273 48 08.77	93 49 41.83	Fort Tompkins 2	3368^{m}.81	3.5274771
			11052^{ft}.52	
331 00 22.15	151 01 06.50	New Creek	3306^{m}.85	3.5194150
			10849^{ft}.24	
359 59 23.52	179 59 23.54	Northeast base	2475^{m}.11	3.3935952
			8120^{ft}.44	
28 20 07.21	208 19 44.36	Cromwell	1739^{m}.74	3.2404846
			5707^{ft}.80	

No.	To Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
20	Lambert	40 36 58.715	1811^{m}.1 5941^{ft}.9	74 09 51.849	1218^{m}.8 3998^{ft}.7
21	Linoleumville schoolhouse	40 35 30.041	926^{m}.6 3040^{ft}.0	74 11 26.371	620^{m}.1 2034^{ft}.4
22	Northeast base	40 35 02.893	89^{m}.2 292^{ft}.7	74 05 46.387	1090^{m}.9 3579^{ft}.1

RICHMOND.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
85 09 04.58	265 08 09.15	Bloomfield church	2008^{m}.88	3.3029535
			6590^{ft}.79	
188 36 37.82	8 36 46.17	Summerfield church	2015^{m}.70	3.3044260
			6613^{ft}.18	
224 24 51.86	44 25 36.44	Quarry Hill school-house	2299^{m}.78	3.3616871
			7545^{ft}.19	
264 51 24.82	84 52 37.36	Westerleigh school-house	2630^{m}.18	3.4199860
			8629^{ft}.19	
291 03 45.10	111 05 38.25	Bogart	4379^{m}.77	3.6414511
			14369^{ft}.29	
357 47 23.72	177 47 25.71	Asbury church	1859^{m}.09	3.2693005
			6099^{ft}.37	
208 04 58.89	28 06 08.78	Summerfield church	5359^{m}.64	3.7291357
			17584^{ft}.09	
259 33 30.07	79 36 24.70	Bogart	6415^{m}.73	3.8072458
			21048^{ft}.93	
285 24 48.31	105 27 01.46	Wyeth	4993^{m}.14	3.6983738
			16381^{ft}.66	
359 00 03.46	179 00 05.79	Jessup	4833^{m}.83	3.6842917
			15859^{ft}.00	
359 13 02.64	179 13 03.48	Elm Tree	2239^{m}.61	3.3501724
			7347^{ft}.79	
29 15 28.45	209 14 05.59	Great Kills	6136^{m}.38	3.7879126
			20132^{ft}.46	
37 55 10.81	217 54 19.53	Southwest base	3017^{m}.97	3.4797145
			9901^{ft}.45	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
22	Northeast base—*Continued.*				
23	New Creek.....	40 34 49.358	1522^{m}.5 4995^{ft}.1	74 04 38.253	899^{m}.6 2951^{ft}.4
24	Old Orchard lighthouse	40 30 44.250	1364^{m}.9 4478^{ft}.0	74 05 56.740	1335^{m}.9 4382^{ft}.9

RICHMOND.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
81	14	14.88	261	12	46.84	Wyeth	3220^{m}.21	3.5078839
							10564^{ft}.97	
139	52	09.18	319	51	22.57	Bogart	2612^{m}.78	3.4171023
							8572^{ft}.09	
40	47	43.23	220	46	59.76	Elm Tree	2406^{m}.41	3.3813690
							7895^{ft}.02	
89	08	06.29	269	05	53.95	Wyeth	4785^{m}.63	3.6799390
							15700^{ft}.85	
104	36	31.25	284	35	46.93	Northeast base	1655^{m}.89	3.2190314
							5432^{ft}.70	
126	19	17.29	306	17	46.36	Bogart	4078^{m}.35	3.6104844
							13380^{ft}.38	
213	23	30.68	33	24	19.37	Fort Tompkins 2	3196^{m}.24	3.5046394
							10486^{ft}.33	
104	38	32.18	284	35	49.23	Barclay	6102^{m}.16	3.7854837
							20020^{ft}.18	
133	36	10.71	313	34	54.64	Great Kills	3805^{m}.18	3.5803750
							12484^{ft}.16	
158	34	02.58	338	32	41.36	Wyeth	8043^{m}.48	3.9054439
							26389^{ft}.32	
171	46	56.63	351	46	16.80	Bogart	10079^{m}.03	4.0034185
							33067^{ft}.60	
182	44	05.74	2	44	13.31	Elm Tree	5745^{m}.07	3.7592954
							18848^{ft}.62	
199	24	33.98	19	26	13.67	Fort Tompkins 2	10846^{m}.15	4.0352757
							35584^{ft}.42	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
25	Old Place.....	40 37 55.234	$1703^{m}.7$	74 11 19.520	$458^{m}.7$
			$5589^{ft}.6$		$1504^{ft}.9$
26	Princess Bay lighthouse	40 30 27.584	$850^{m}.8$	74 12 49.585	$1167^{m}.5$
			$2791^{ft}.3$		$3830^{ft}.4$
27	Quarry Hill schoolhouse	40 37 51.966	$1602^{m}.9$	74 08 43.365	$1019^{m}.1$
			$5258^{ft}.8$		$3343^{ft}.5$
28	Rossville.....	40 32 39.605	$1221^{m}.6$	74 13 07.737	$182^{m}.1$
			$4007^{ft}.9$		$597^{ft}.4$

RICHMOND.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
263	57	31.02	83	58	36.47	Summerfield Church....	2375^{m}.25	3.3757086
							7792^{ft}.79	
287	50	34.88	107	52	44.51	Westerleigh schoolhouse	4916^{m}.85	3.6916872
							16131^{ft}.38	
298	20	20.41	118	23	10.65	Bogart.....	6985^{m}.60	3.8442036
							22918^{ft}.59	
2	03	36.45	182	03	31.99	Linoleumville schoolhouse.....	4481^{m}.49	3.6514220
							14703^{ft}.01	
174	00	42.89	354	00	31.08	Rossville.....	4094^{m}.58	3.6122090
							13433^{ft}.63	
204	25	39.69	24	26	36.09	Jessup.....	4938^{m}.65	3.6936083
							16202^{ft}.89	
241	40	43.95	61	42	29.21	Barclay.....	4332^{m}.15	3.6367087
							14213^{ft}.07	
245	42	44.67	65	45	56.83	Great Kills.....	7636^{m}.61	3.8829004
							25054^{ft} 43	
322	24	27.46	142	25	36.05	Bogart.....	4060^{m}.34	3.6085621
							13321^{ft}.29	
324	20	10.61	144	20	38.58	Westerleigh schoolhouse	1732^{m}.00	3.2385477
							5682^{ft}.40	
41	12	40.48	221	10	54.37	Linoleumville schoolhouse.....	5818^{m}.00	3,7647736
							19087^{ft}.89	
105	00	23.21	284	59	46.97	Summerfield church	1355^{m}.80	3.1315535
							4441^{ft}.58	
204	23	18.64	24	24	24.56	Linoleumville schoolhouse.....	5772^{m}.65	3.7613756
							18939^{ft}.10	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
28	Rossville—*Continued.*				
29	St. George schoolhouse.	40 38 42.916	1323^{m}.7 4342^{ft}.8	74 04 54.639	1283^{m}.8 4211^{ft}.9
30	St. Michaels.....	40 33 40.977	1263^{m}.9 4146^{ft}.6	74 11 07.218	169^{m}.8 557^{ft}.1

RICHMOND.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
233	32	33.50	53	36	33.97	Bogart	10807^{m}.88	4.0337403
							35458^{ft}.85	
241	21	09.69	61	24	28.69	Wyeth	8201^{m}.61	3.9138993
							26908^{ft}.12	
260	14	49.16	80	15	57.38	Jessup	2505^{m}.70	3.3989282
							8220^{ft}.78	
14	49	47.11	194	49	28.19	Kendall	2667^{m}.66	3.4261301
							8752^{ft}.14	
79	40	09.02	259	37	03.80	Summerfield church	6792^{m}.85	3.8320522
							22286^{ft}.22	
187	24	21.43	7	24	54.20	Bergen Dutch Reformed church	9151^{m}.72	3.9615029
							30025^{ft}.28	
252	36	08.82	72	40	36.47	Prospect water tower	10110^{m}.89	4.0047894
							33172^{ft}.15	
314	07	04.32	134	08	58.53	Ft. Hamilton flag staff	5743^{m}.46	3.7591734
							18843^{ft}.33	
334	41	45.76	154	42	45.14	Fort Tompkins 2	5016^{m}.87	3.7004331
							16459^{ft}.53	
14	00	20.16	194	00	10.04	Jessup	1513^{m}.94	3.1801086
							4966^{ft}.98	
56	17	06.67	236	15	48.32	Rossville	3409^{m}.48	3.5326879
							11185^{ft}.93	
172	22	28.94	352	22	16.48	Linoleumville schoolhouse	3394^{m}.19	3.5307355
							11135^{ft}.76	
244	58	32.56	65	00	33.21	Wyeth	4815^{m}.08	3.6826032
							15797^{ft}.49	

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
31	Sharrot.....	40	31	32.978	1017^{m}.2	74	12	54.942	1293^{m}.3
					3337^{ft}.3				4243^{ft}.1
32	Snug Harbor church...	40	38	36.611	1129^{m}.3	74	06	04.343	102^{m}.0
					3705^{ft}.0				334^{ft}.6
33	Stapleton schoolhouse..	40	37	31.425	969^{m}.3	74	04	41.235	969^{m}.2
					3180^{ft}.1				3179^{ft}.8

RICHMOND.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
171 39 52.56	351 39 44.23	Rossville	2077^{m}.08	3.3174526
			6814^{ft}.54	
221 10 13.88	41 11 13.77	Jessup	3293^{m}.91	3.5177119
			10806^{ft}.77	
269 26 40.11	89 28 28.86	Barclay	3939^{m}.87	3.5954815
			12926^{ft}.04	
356 25 20.64	176 25 24.12	Princess Bay lighthouse	2021^{m}.03	3.3055732
			6630^{ft}.67	
15 21 24.13	195 20 49.18	Bogart	4764^{m}.83	3.6780477
			15632^{ft}.62	
57 44 23.27	237 43 45.18	West Brighton schoolhouse	1625^{m}.01	3.2108572
			5331^{ft}.40	
69 47 04.33	249 45 20.75	Quarry Hill schoolhouse	3982^{m}.54	3.6001597
			13066^{ft}.04	
89 08 31.78	269 06 41.00	Bergen Point lighthouse	3996^{m}.29	3.6016573
			13111^{ft}.17	
263 13 18.50	83 14 03.90	St. George schoolhouse	1649^{m}.33	3.2173070
			5411^{ft}.17	
69 28 30.69	249 28 03.05	Kendall	1065^{m}.47	3.0275403
			3495^{ft}.62	
171 52 19.57	351 52 10.85	St. George schoolhouse	2227^{m}.58	3.3478335
			7308^{ft}.32	
321 52 15.53	141 53 06.18	Fort Tompkins 2	2962^{m}.55	3.4716655
			9719^{ft}.63	
349 07 59.96	169 08 10.13	Fox Hills	1947^{m}.42	3.2894591
			6389^{ft}.15	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
34	Summerfield church...	40 38 03.326	$102^{m}.6$	74 09 39.008	$916^{m}.7$
			$336^{ft}.6$		$3007^{ft}.5$
35	S. S. White.....	40 30 41.297	$1273^{m}.8$	74 11 47.524	$1118^{m}.9$
			$4179^{ft}.1$		$3670^{ft}.9$
36	Southwest base.....	40 33 45.701	$1409^{m}.7$	74 07 05.226	$122^{m}.9$
			$4625^{ft}.0$		$403^{ft}.2$
37	Tottenville schoolhouse	40 30 30.860	$951^{m}.9$	74 14 38.187	$897^{m}.9$
			$3123^{ft}.0$		$2945^{ft}.9$

RICHMOND.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
236	23	57.91	56	29	56.19	Park Row building	15492^{m}.51	4.1901219
							50828^{ft}.36	
255	23	23.82	75	30	56.71	Prospect water tower	16872^{m}.85	4.2271884
							55357^{ft}.01	
313	18	04.39	133	19	49.20	Bogart	5201^{m}.21	3.7161042
							17064^{ft}.30	
73	51	40.48	253	51	00.16	Princess Bay light-house	1521^{m}.15	3.1821711
							4990^{ft}.63	
135	08	00.46	315	07	16.66	Sharrot	2249^{m}.44	3.3520744
							7380^{ft}.04	
188	07	54.61	8	08	10.68	Jessup	4114^{m}.71	3.6143393
							13499^{ft}.68	
21	02	25.74	201	01	54.16	Great Kills	3185^{m}.43	3.5031682
							10450^{ft}.87	
144	53	49.89	324	53	13.16	Wyeth	2310^{m}.05	3.3636207
							7578^{ft}.88	
265	41	48.24	85	42	40.35	Elm Tree	1890^{m}.59	3.2765985
							6202^{ft}.73	
208	10	30.29	28	11	29.02	Rossville	4505^{m}.32	3.6537253
							14781^{ft}.19	
226	16	25.79	46	18	32.73	Jessup	6360^{m}.78	3.8035101
							20868^{ft}.65	
231	43	39.49	51	44	46.53	Sharrot	3094^{m}.02	3.4905235
							10150^{ft}.97	
272	15	15.65	92	16	26.16	Princess Bay light-house	2557^{m}.79	3.4078648
							8391^{ft}.68	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
38	Westerleigh schoolhouse	40 37 06.344	195m.7 642ft.1	74 08 00.405	9m.5 31ft.2
39	West Brighton schoolhouse	40 38 08.487	261m.8 858ft.9	74 07 02.819	66m.2 217ft.2
40	Wyeth	40 34 46.967	1448m.7 4752ft.9	74 08 01.707	40m.1 131ft.6
*	Ft. Wadsworth lighthouse	40 36 20.924	645m.4	74 03 15.600	366m.8

*The position of Ft. Wadsworth lighthouse is given, but it is not a part of the Richmond triangulation.

RICHMOND.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
58	29	29.52	238	27	15.47	Linoleumville schoolhouse	5680^{m}.89	3.7544165
							18638^{ft}.06	
127	11	13.30	307	10	09.10	Summerfield church	2908^{m}.61	3.4636852
							9542^{ft}.66	
263	47	18.66	83	49	00.70	Kendall	3705^{m}.31	3.5688247
							12156^{ft}.51	
320	58	54.80	140	59	35.42	Bogart	2330^{m}.05	3.3673652
							7644^{ft}.51	
358	15	48.93	178	15	52.05	Bogart	3729^{m}.02	3.5715952
							12234^{ft}.31	
77	50	18.14	257	49	12.66	Quarry Hill schoolhouse	2417^{m}.20	3.3833127
							7930^{ft}.43	
87	31	50.76	267	30	09.04	Summerfield Church	3673^{m}.88	3.5651249
							12053^{ft}.39	
250	33	59.10	70	35	22.59	St. George schoolhouse	3193^{m}.72	3.5042972
							10478^{ft}.07	
303	03	27.76	123	04	32.30	Kendall	2780^{m}.07	3.4440553
							9120^{ft}.96	
53	29	09.08	233	26	58.32	Jessup	5887^{m}.12	3.7699026
							19314^{ft}.65	
211	02	06.12	31	02	47.56	Bogart	2904^{m}.66	3.4630960
							9529^{ft}.72	
357	48	51.86	177	48	56.99	Great Kills	4866^{m}.46	3.6872127
							15966^{ft}.03	

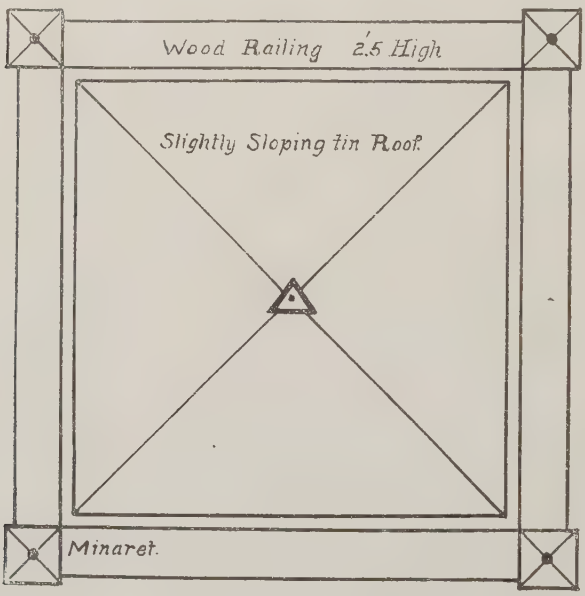
ASBURY CHURCH.

This station is the pole erected on the roof of the tower of the Asbury M. E. Church, Old Stone road, Springville, Borough of Richmond, New York City, N. Y.

The church is of brick, the tower of wood, painted brown. It is square in plan, with slightly sloping tin roof with ornamental minarets 13 feet high on each corner.

Reached by Shore Line car to Port Richmond, thence by Bulls Head car to Bulls Head, thence walk south to station.

ASBURY CH.

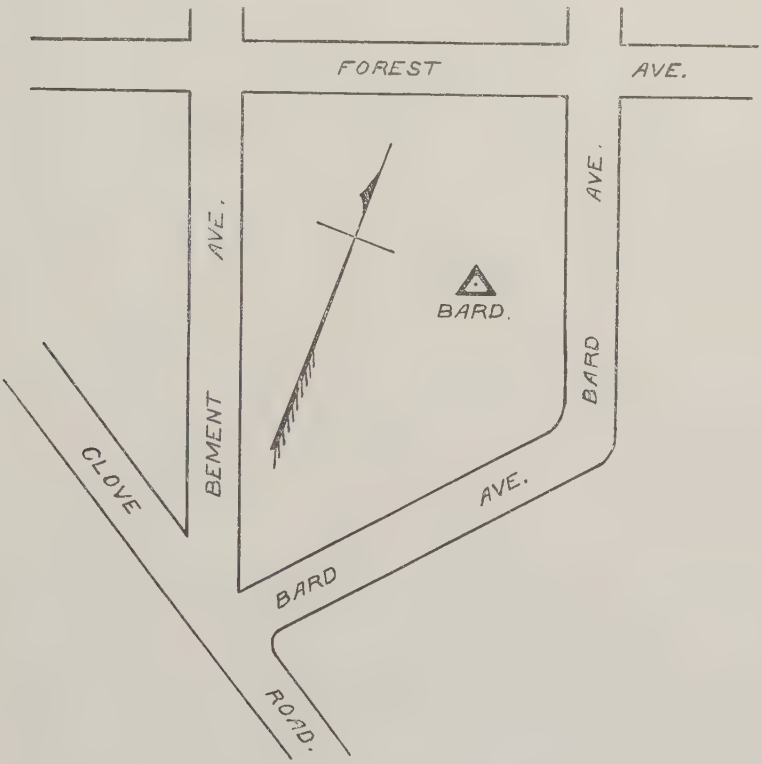


BARD.

This station is a 15-foot tripod and scaffold situated in a field of brushwood in block bounded by Bard, Bement and Forest avenues, Borough of Richmond, New York City, N. Y.

The station is marked with the regular U. S. C. & G. S. brass marking bolt set in rock. The exact point is a small hole drilled in top of bolt.

Reached by Port Richmond trolley to Clove road, walking west to Bard avenue, thence across field to station.

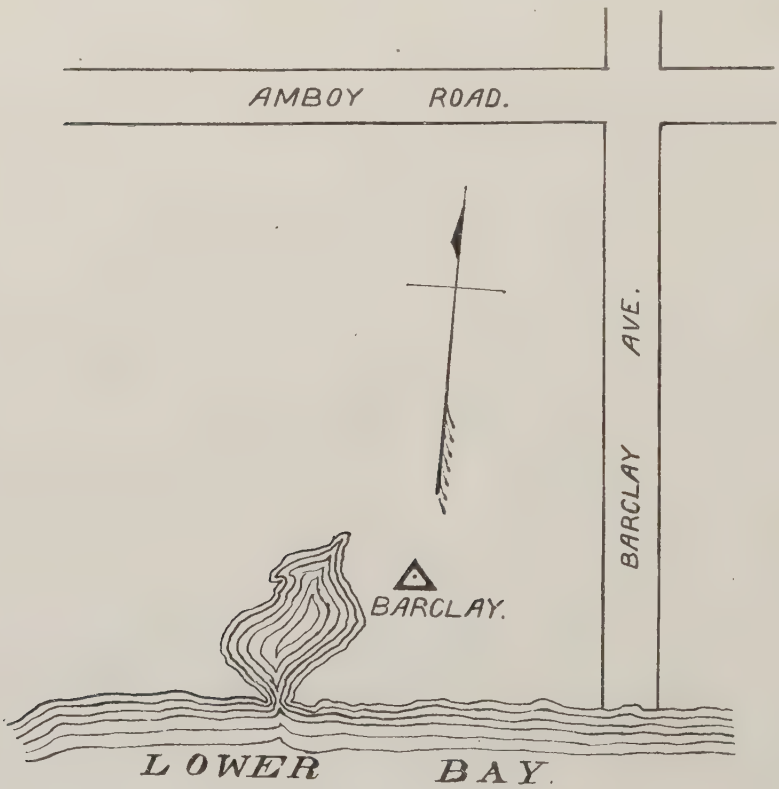


BARCLAY.

This station is a 68-foot tripod and scaffold situated east of gulley, near the foot of Barclay avenue, Annadale, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′ with a crosscut + on top of bolt marking the center.

Station is reached by S. I. R. T. R. R. to Annadale, thence by hack to station.

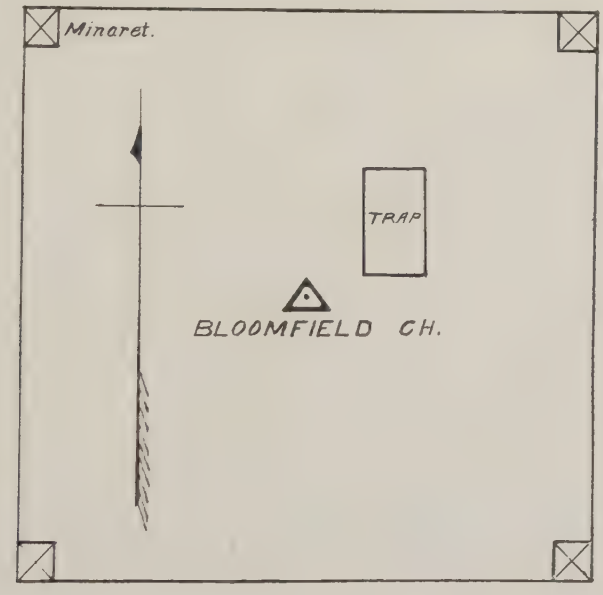


BLOOMFIELD CHURCH.

This station is a pole erected on the tower of Bloomfield M. E Church, on Merrill road, Bloomfield, Borough of Richmond, New York City, N. Y.

The church is one story high, of wood, painted white. The tower is open, square in plan, with flat board roof, on each corner of which is a small minaret 4 feet high. The whole building is very unsteady and an attempt was made to brace the roof, but it was only partially successful.

Reached by Shore Line trolley to Port Richmond, thence by Bulls Head car to Merrill road, thence by hack to Bloomfield.

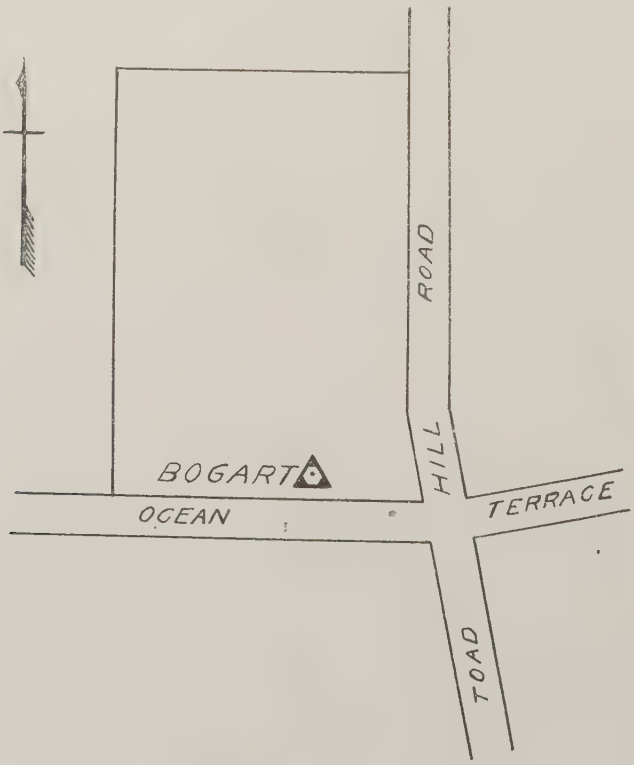


BOGART.

This station is the northwest corner of Ocean Terrace and Toad Hill road, Castleton Corner, Borough of Richmond, New York City, N. Y.

It is reached by Silver Lake trolley to Eckstein's Brewery, or by S. I. R. R. at St. George ferry to West Brighton Station and thence by Manor road trolley at foot of Broadway to Eckstein's Brewery, where a half-mile walk brings one to the hill, to the south of which station is located. Land was bought by the City of New York and a tripod and scaffold 78 feet high erected over a bottle marking old station. The station when recovered was about 1′ 6″ below surface (neck downward). The earth around the bottle seemed very soft, showing evidence of having been uncovered at some recent time for below the top it is badly cracked. Upon occupation of the signal the tripod was found to have settled. The amount is noted in the observations.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

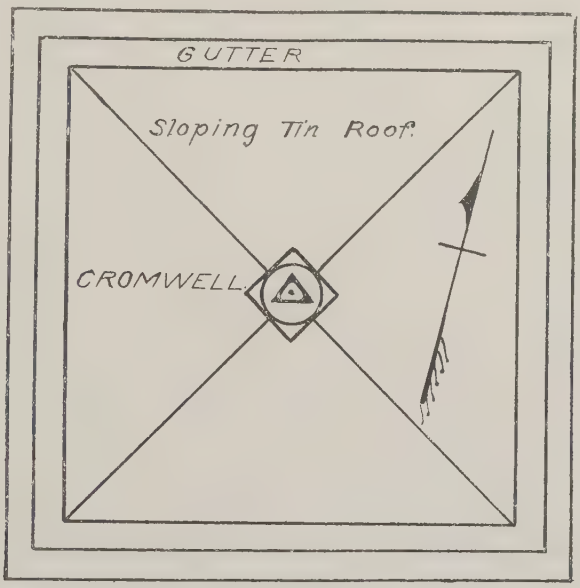


CROMWELL.

This station is a temporary pole erected on the cupola of the residence of Borough President Cromwell, Dongan Hills, Borough of Richmond, New York City, N. Y.

The house is of wood, painted white. The cupola is located on the easterly end of the house. It is square in plan with a sloping flat tin roof.

Reached by Richmond car to Bourquire's Hotel, thence walk northwest to station.

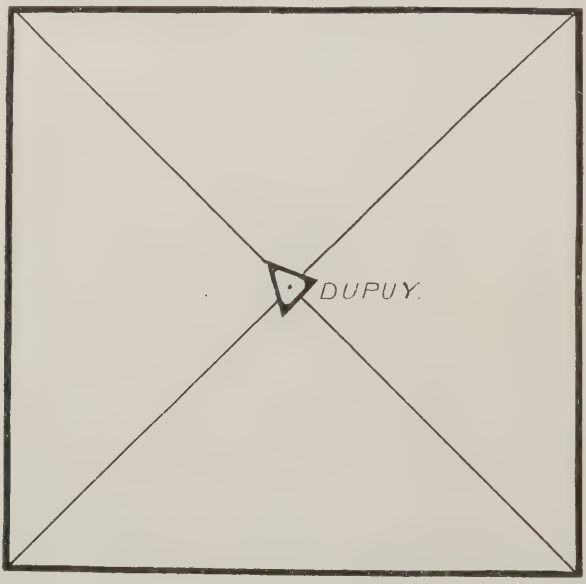


DUPUY.

This station is a temporary pole erected on the cupola of Mr. Dupuy's residence, situated on the old Stone road, in New Springfield, Borough of Richmond, New York City, N. Y.

The building is of wood, painted white, with dark brown trim. The cupola is square in plan with slightly sloping flat tin roof.

Reached by Shore Line car from St. George to Port Richmond, thence by Bulls Head car to Bulls Head, thence by hack to station.

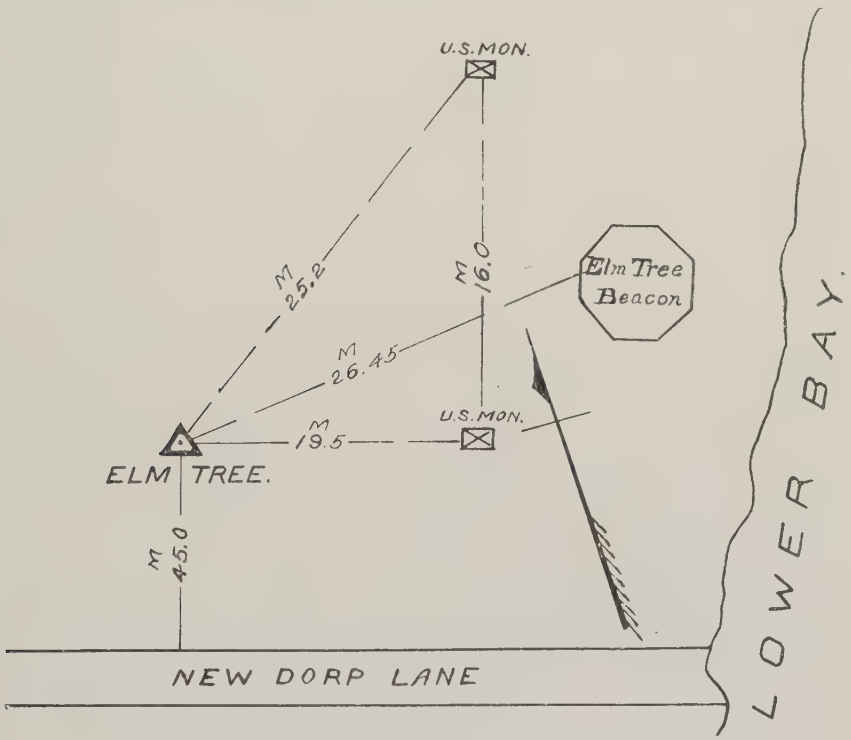


ELM TREE.

This station consists of a 68-foot tripod and scaffold and is situated in New Dorp, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A small hole on top of bolt marks the center.

Reached by Midland Beach trolley from St. George to Midland Beach, thence walking south one-half mile to station, or by train to New Dorp and carriage to station.



FORT TOMPKINS.[2]

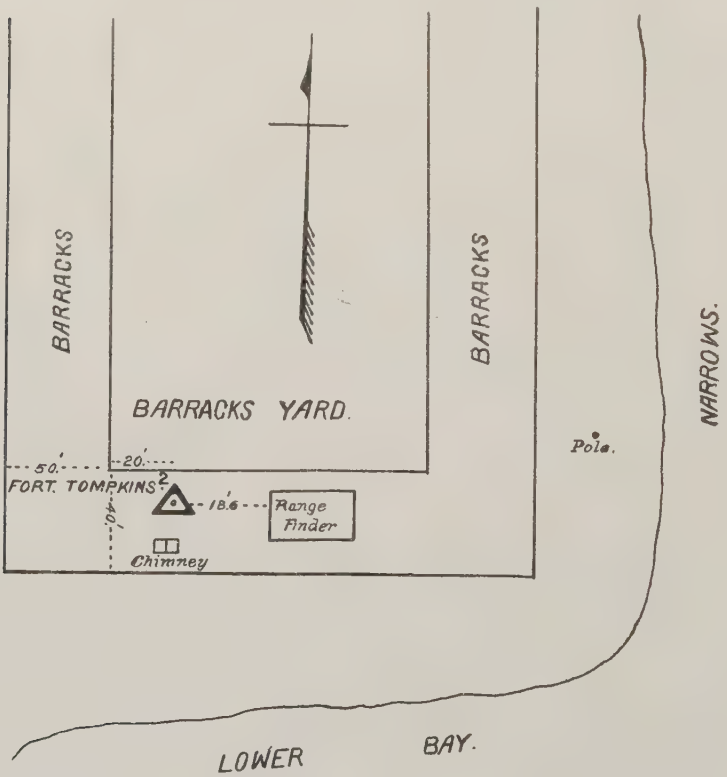
This station is situated on top of the old magazine at the west end of the southern face of the new fort.

The station was occupied on the ground by Mr. Frederick W. Koop in 1904, having been recovered with tripod pole standing over wooden plug, which was removed, and the stone and plate marked station, mentioned below, inserted.

A 15-foot tripod and scaffold has been built over the station, and the line to Bogart and Sandy Hook is now cleared.

The station is marked by a granite block 18″ x 21″ x 9″ placed over the airhole and set in neat cement. An iron plate 7″ x 16″ x 1″ was set on top of the block and securely bolted to it. A hole three-eighths of an inch in diameter set in station marks the center of the station.

Station is reached by trolley from St. George to Fort Tompkins.

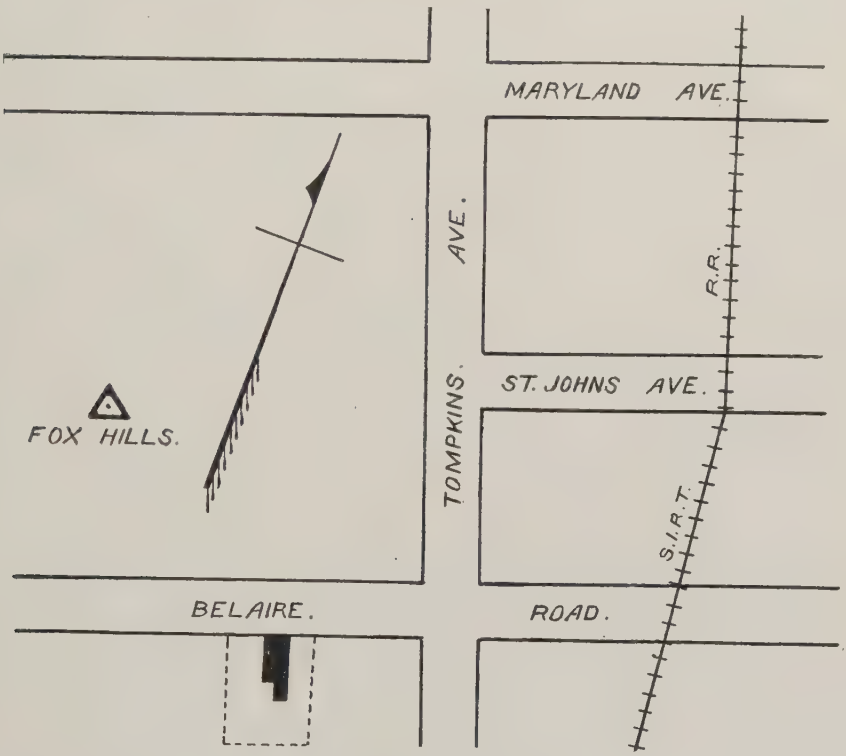


FOX HILLS.

This station is a 15-foot tripod and scaffold situated on a high hill about 500 feet west of Tompkins avenue, between Belaire road and Maryland avenue, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A crosscut + on top of bolt marks the center.

The station is reached by S. I. R. T. R. R., South Beach Division, to Belaire road station, thence walking west on Belaire road one-quarter of a mile to station.

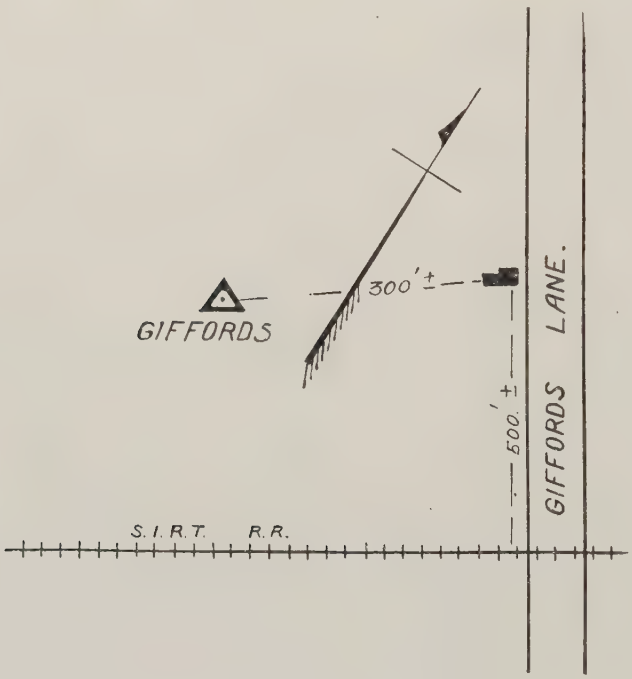


GIFFORDS.

This station is an 84-foot tripod and scaffold situated about 300 feet west of Giffords Lane, in a thick woods, at Giffords, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Station is reached by S. I. R. T. R. R. to Great Kills station, thence walking north on Giffords lane 500 feet, then west through woods to station.



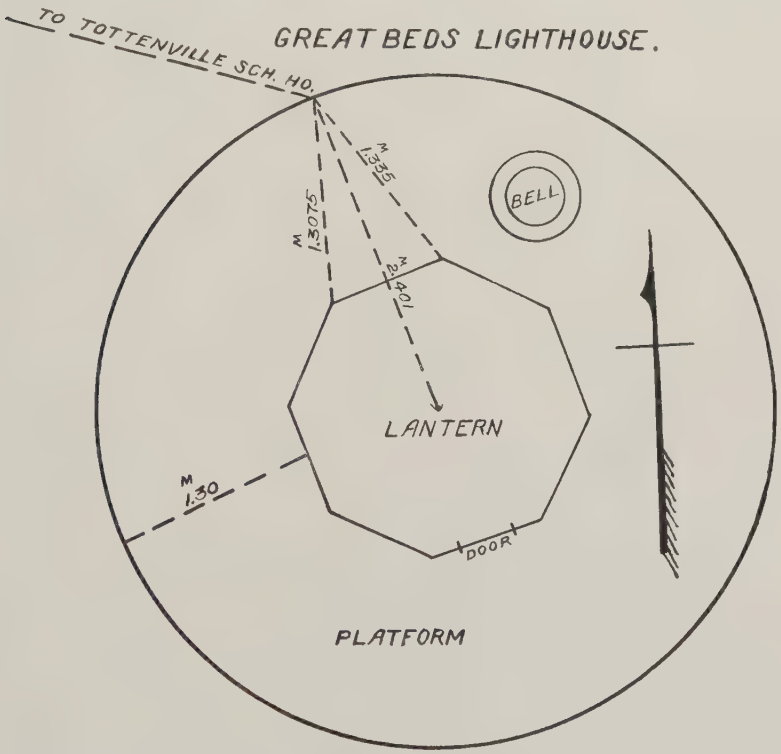
GREAT BEDS LIGHTHOUSE.

This station is the lightning rod on the lantern of the Great Beds Lighthouse.

The lighthouse is situated in Raritan Bay about one mile from Staten Island shore.

An eccentric station was established on the north side of lantern on platform close to railing. The instrument was mounted on a stand made of 6″ x 6″ timber, which was secured firmly to railing with hook bolts, making a very firm support.

Station is reached by S. I. R. T. R. R. to Perth Amboy, N. J.; thence by boat to lighthouse.



GREAT KILLS.

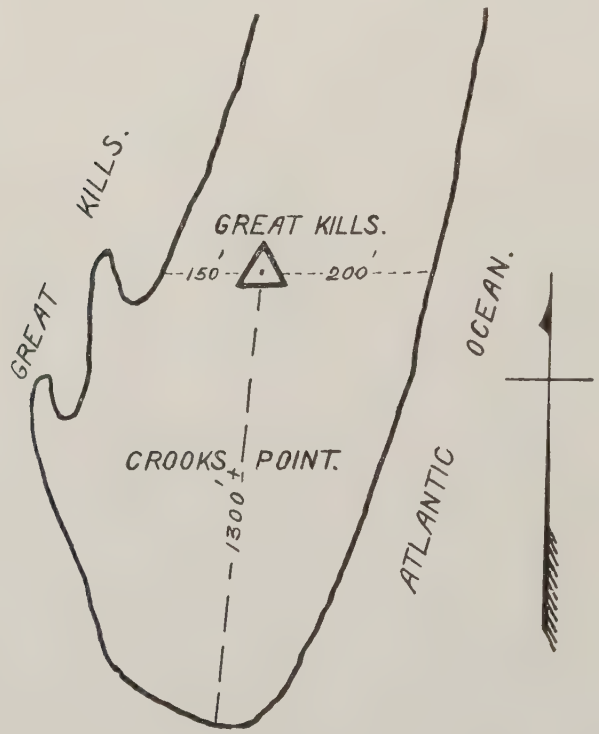
This station is situated on Crooks Point, Borough of Richmond, New York City, N. Y.

It is the same station occupied on the ground by Mr. Geo. Wood in 1904. It consists of a 68-foot tripod and scaffold, and is marked with the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Mr. Wood marked the station with drain tile pipe, underneath of which was a glass bottle set in concrete. These marks were referenced to trees up to 150 feet distant.

When the center of the present tower was plumbed down with vertical collimator it was found to agree with the references.

Station is reached by the Staten Island ferry to St. George, thence by Staten Island R. R. to Great Kills, thence by hack to Gillis Hotel, where a boat can be obtained to take one over to station.



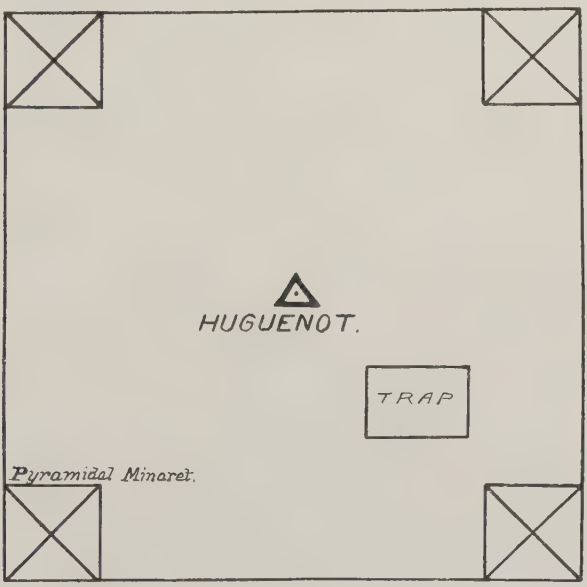
HUGUENOT CHURCH.

This station is a pole erected on the tower of Huguenot Reformed Church on the Amboy road, Huguenot Park, Borough of Richmond, New York City, N. Y.

The tower is of dark reddish brown wood, square in plan, with flat square roof supporting a pyramidal minaret 3 feet high at each corner.

The station is a brass tack driven in the socket attached to the base structure of the pole.

Reached by Perth Amboy Division of the S. I. R. T. R. R. to Huguenot Park, thence walk southeast to church.



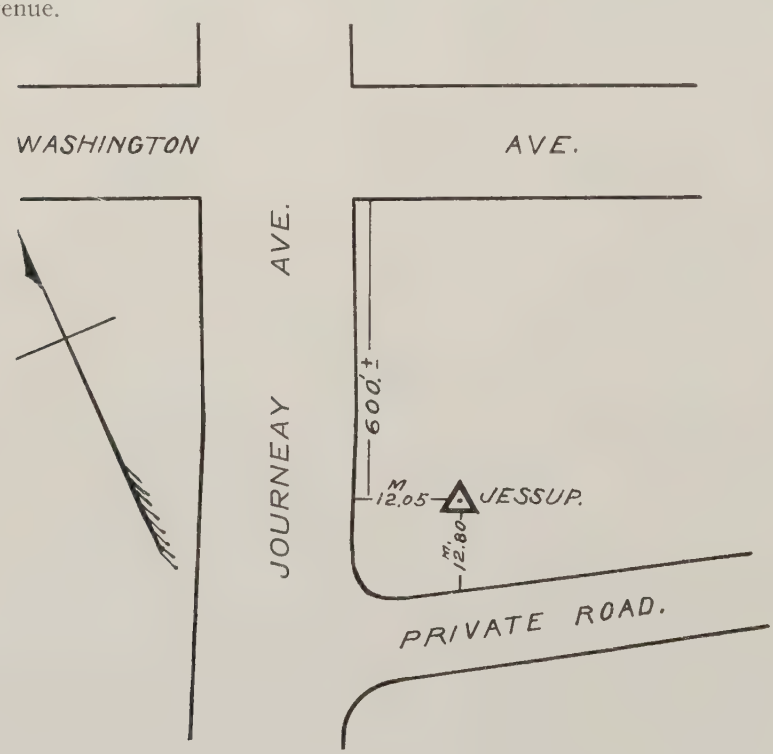
JESSUP.

This station consists of an 84-foot tripod and scaffold, situated between Rossville and Annadale, Borough of Richmond, New York City, N. Y.

The station is on the estate of Thos. H. Rothwell, formerly Isaac Jessups, and is situated as shown in sketch.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A small hole drilled in top of bolt marks the center.

Reached by S. I. R. T. R. R. from St. George and getting off at Huguenot or Annadale, thence walking west one-half mile to Journeay avenue.



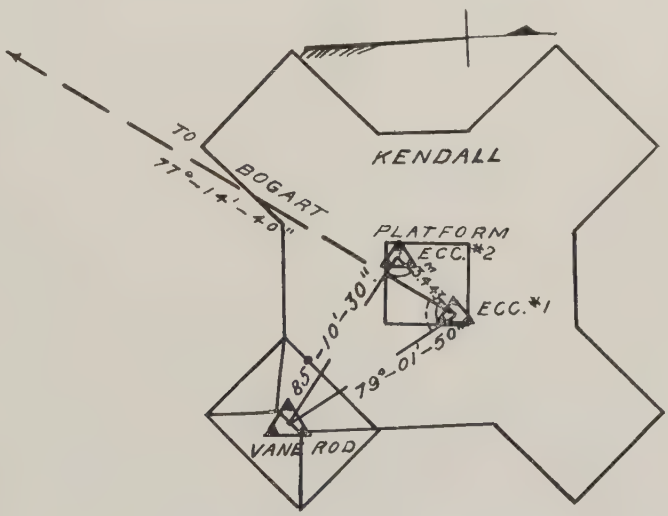
KENDALL.

This station is the iron vane rod on the pyramidal tower on the residence of Mr. Kendall.

It is reached by Staten Island ferry to St. George, then by Silver Lake trolley to Eddy street, one block south on Eddy street to Serpentine road and thence one-half mile west on Serpentine road to large iron ornamental gate fixed in a stone wall in front of the property, which is the main entrance.

The tower is impossible of occupation, and as the trees surrounding house are of such a height as to prevent observations being taken from roof near tower; they were obtained from an observation platform on roof. This platform was so shaky as to make all pointings very difficult, the observer having to lay planks across the railings to sit upon while making observations.

In order to get eccentric distance a small base was measured on this platform and necessary angles taken.

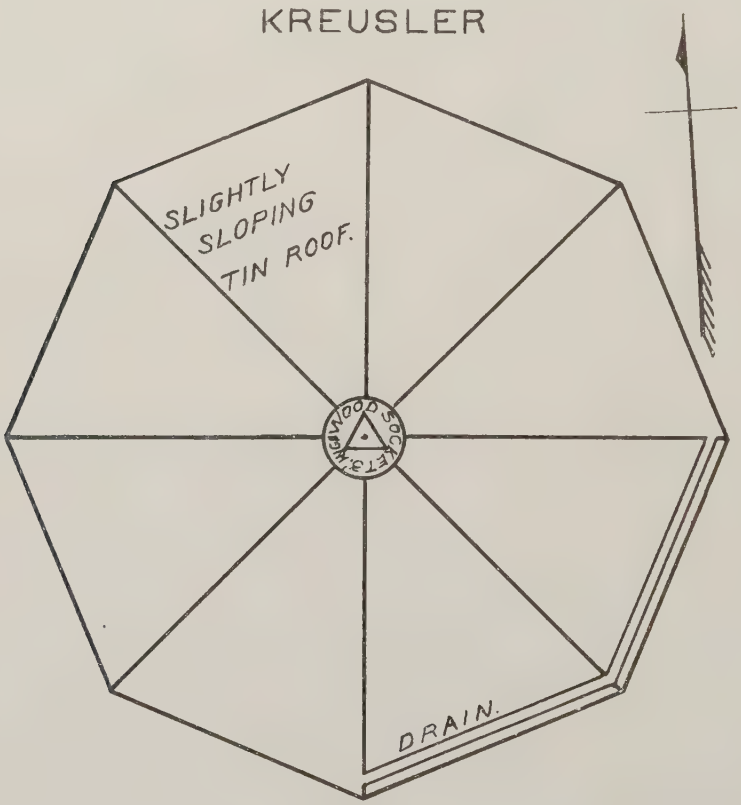


KREUSLER.

This station is a signal pole erected on the cupola of a two-story frame house, known as "Kreusler's House," on the Kills road about two miles north of Tottenville, Borough of Richmond, New York City, N. Y.

The cupola is octagonal with slightly sloping tin roof. The station is marked by a brass tack driven in the socket of the pole, which rests upon a wooden post some 3 inches high, which forms the center of the cupola. Access to the roof is by ladder from ground up the outside of the roof.

Reached by Perth Amboy division of the S. I. R. T. R. R. to Tottenville, thence by hack to Kreusler.



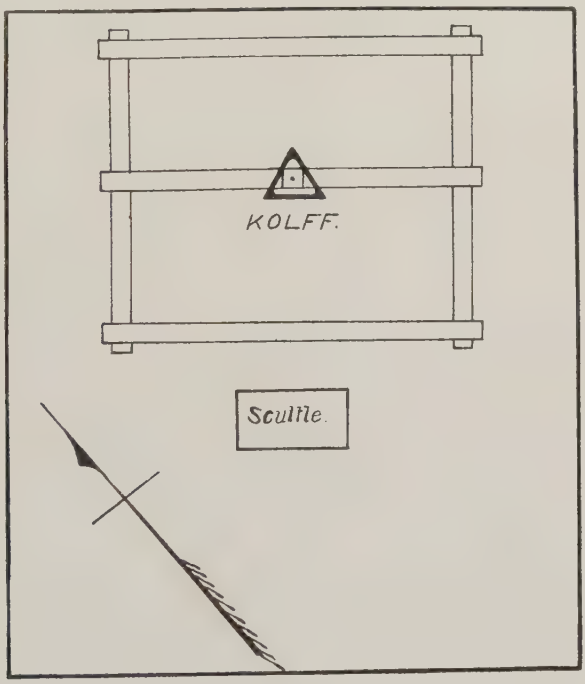
KOLFF.

This station is a pole erected on the roof of the residence of Mr. Kolff, situated on Emerson Hill, Concord, Borough of Richmond, New York City, N. Y.

This building is a two-story frame building, mansard roof, with an open platform 10′ x 20′ on which the pole was erected and center established.

A square frame-work was built, resting on tin roof to support pole, and center marked with brass tack.

Reached by Richmond car from St. George to Emerson Hill.

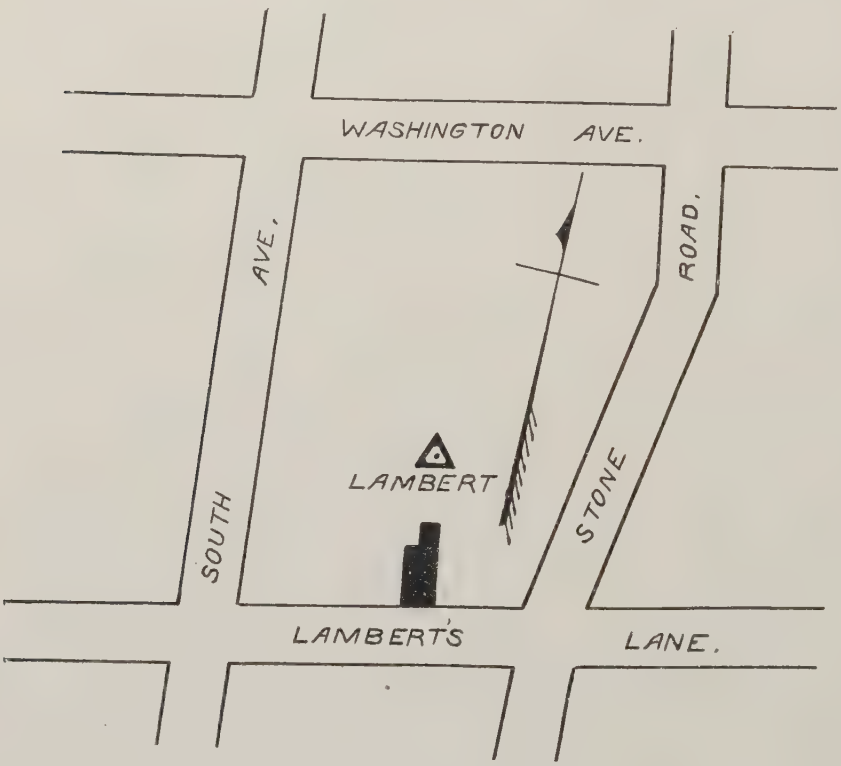


LAMBERT.

This station is a 30-foot tripod and scaffold situated on the farm of Raffael, about 50 feet north of farmhouse, on the north side of Lambert's lane, between Stone road and South avenue, Quarry Hill, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A crosscut + on top of bolt marks the center.

Station is reached by Elizabethport trolley to Bergen Point ferry; thence by Bulls Head trolley to Lambert's lane, walking west to station.



LINOLEUMVILLE SCHOOLHOUSE.

This station is the flagpole on Public School No. 26, corner Melvin avenue and Richmond turnpike, Linoleumville, Borough of Richmond, New York City, N. Y.

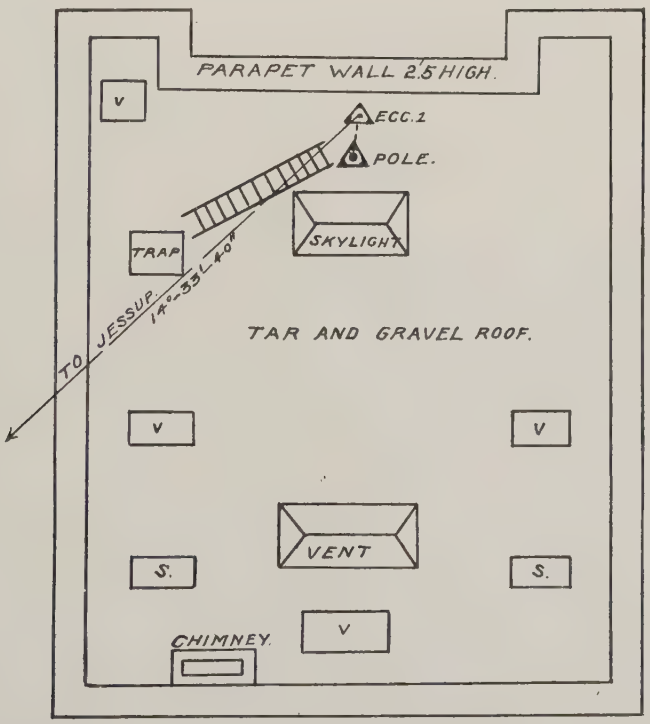
The building is three stories, red brick, flat tar and gravel roof containing a number of skylights and ventilators. The roof is surmounted by a coping two and a half feet high.

July, 1906—Observations on primary stations were made from Eccentric No. 1, on the roof. In the interval between reoccupation for secondary points a 20-foot tripod and scaffold were erected over this eccentric and this was used during reoccupation. The feet of the tripod rested upon the same base structure as two feet of the scaffold. The other two feet of the scaffold rested upon the parapet. The tripod was not very satisfactory, due to this fact, as it was very shaky.

Upon investigation it was found that this tripod had not been built exactly over Eccentric No. 1, and was therefore made Eccentric No. 2. The eccentric stations were established by brass tacks driven in roof.

Reached by Elizabethport trolley to Port Richmond, and transferring to Bulls Head trolley to Bulls Head, thence by hack to Linoleumville.

LINOLEUMVILLE SCH. HO.



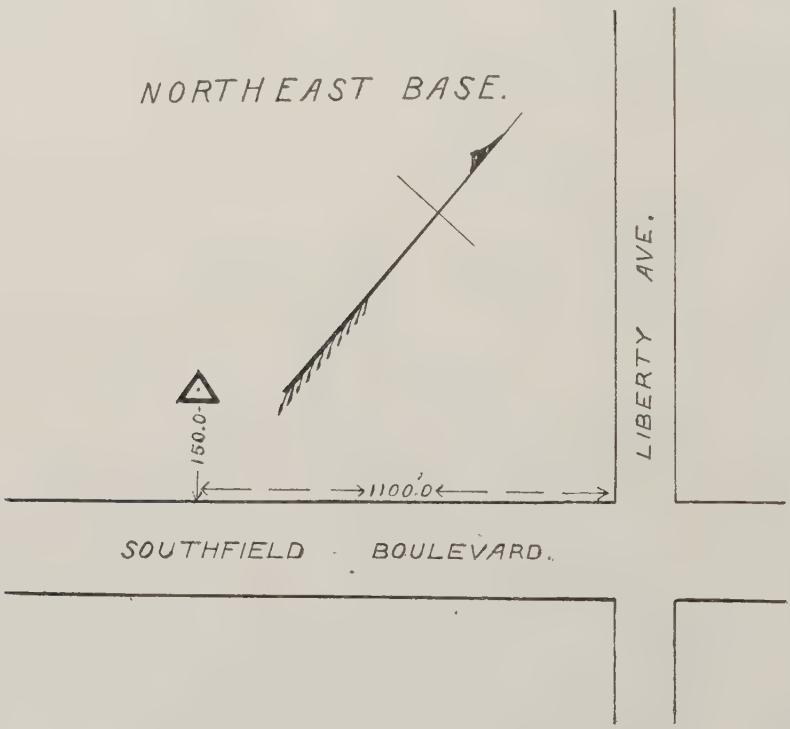
NORTHEAST BASE.

This station is the northeast end of the proposed base line of the Borough of Richmond, New York City, N. Y.

The station consists of a 68-foot tripod and scaffold and is situated 150 feet west of Southfield Boulevard and 1,100 feet south of Liberty avenue, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A small hole drilled in top of bolt marks the center of the station.

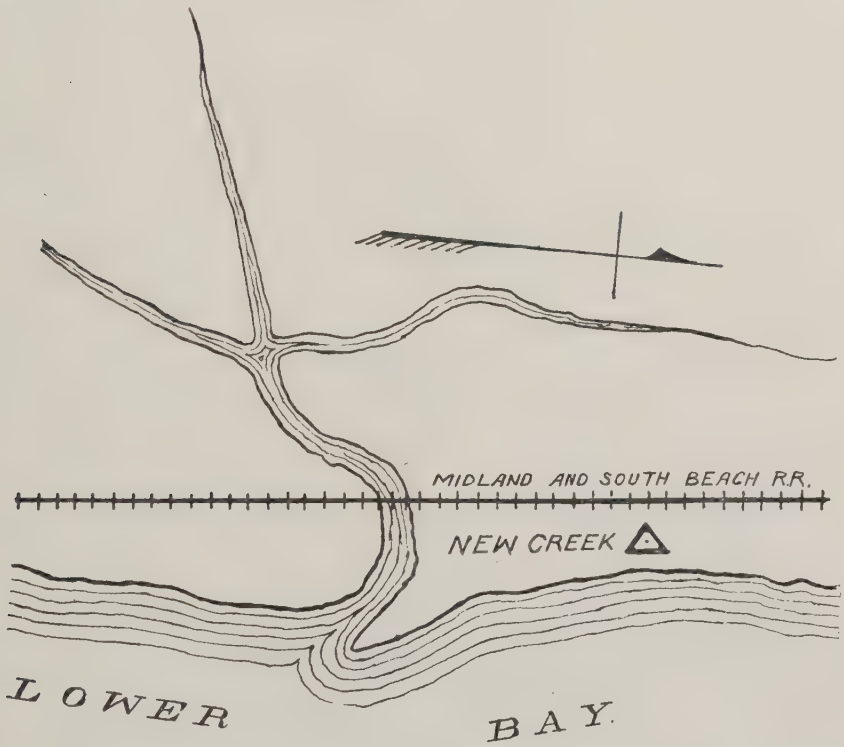
Reached by train to Dongan Hills; thence walking to Southfield Boulevard and to station.



NEW CREEK.

This station is a 30-foot tripod and scaffold situated about halfway between South Beach and Midland Beach in meadow land, 30 feet south of trolley tracks and 200 feet east of New Creek.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A crosscut + on top of bolt marks the station.

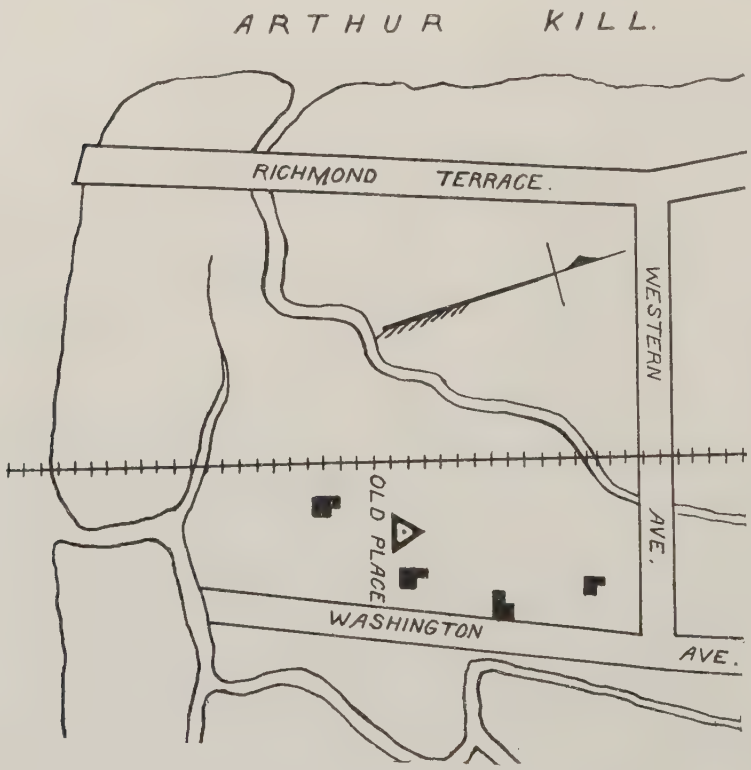


OLD PLACE.

This station is a 30-foot tripod and scaffold situated on the property of Mrs. Howard, 20 feet west of house of Mr. Brooks, Washington avenue, and about 500 feet west of Western avenue, Old Place, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A crosscut + on top of bolt marks the center.

The station is reached by Elizabethport trolley from St. George, getting off at Western avenue and walking south to Washington avenue, thence west to station.



PRINCESS BAY LIGHTHOUSE.

This station is the lightning rod on the lantern of the Princess Bay Lighthouse.

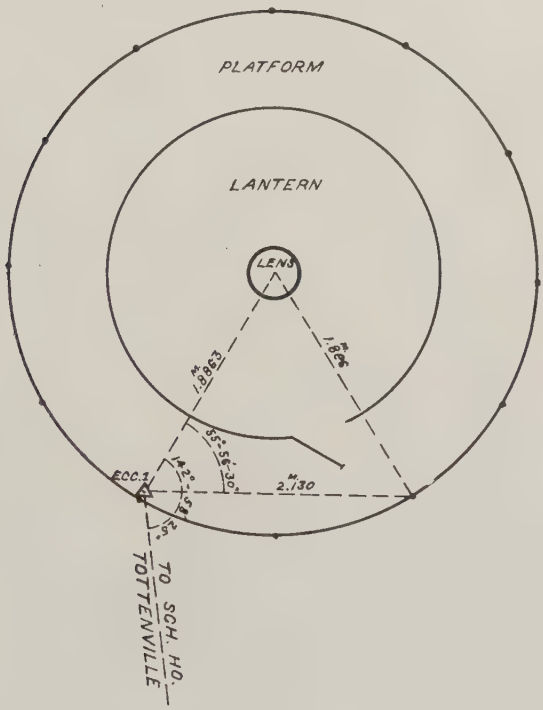
The lighthouse is situated on Government property on high ground on the shore of Princess Bay.

An eccentric station was established on the west side of lantern on platform near railing. As the space on this platform would not permit of the setting up of a tripod the instrument was mounted on a stand made of 6″ x 6″ timber which was secured firmly to railing with hook bolts, making a very firm support.

Eccentric station is 1.8863 meters from center and was measured trigonometrically as shown in sketch.

Reached by S. I. R. T. R. R. to Pleasant Plains, thence by carriage to lighthouse.

PRINCESS BAY LT. HO.



QUARRY HILL SCHOOLHOUSE.

This station is the small pole on the roof of square open tower on Quarry Hill School, situated on block bounded by Morningstar road, Sherman, Sand and Prospect streets, Graniteville, Borough of Richmond, New York City, N. Y.

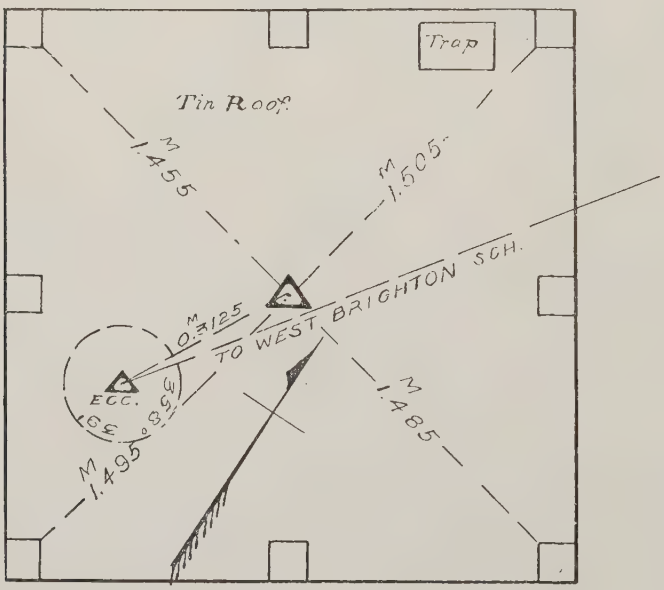
This school is a two-story and attic frame building, with slate mansard roof, in the center of which is a square tower.

The center of pole on roof of tower was dropped to floor by means of transit and center established on which observations were made. Center is marked with brass tack.

An eccentric station was established 0.3125 meter southwest of center and is also marked with brass tack.

Station is reached by S. I. R. T. R. R., North Shore Division, to Elm Park, thence walking south on Morningstar road to Prospect street.

QUARRY HILL SCH. HO.

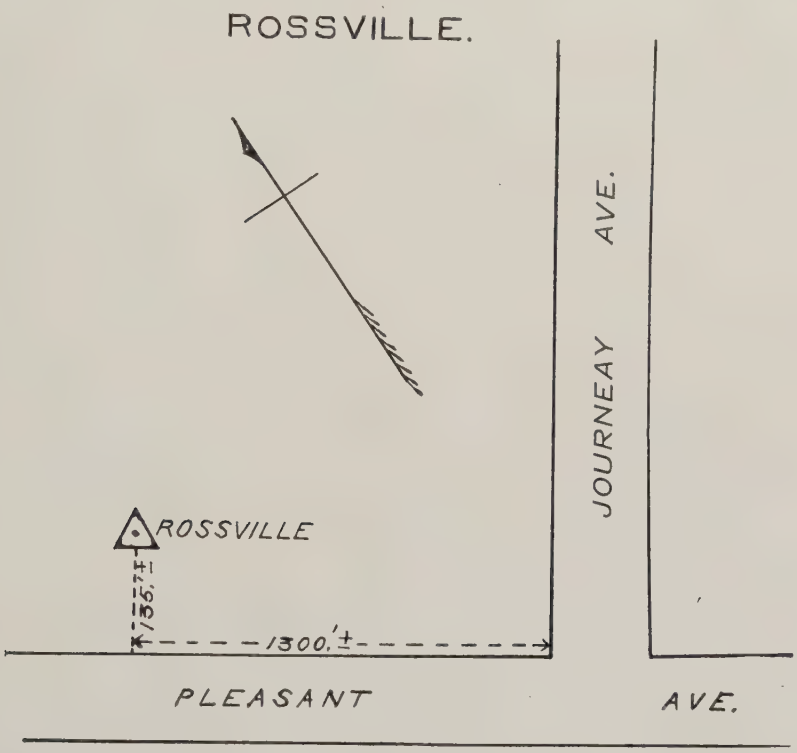


ROSSVILLE.

This station is an 84-foot tripod and scaffold situated about one-half mile south of the Town of Rossville, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A small hole drilled in top of bolt marks the center.

Reached by S. I. R. T. R. R. to Huguenot, thence by stage to station.



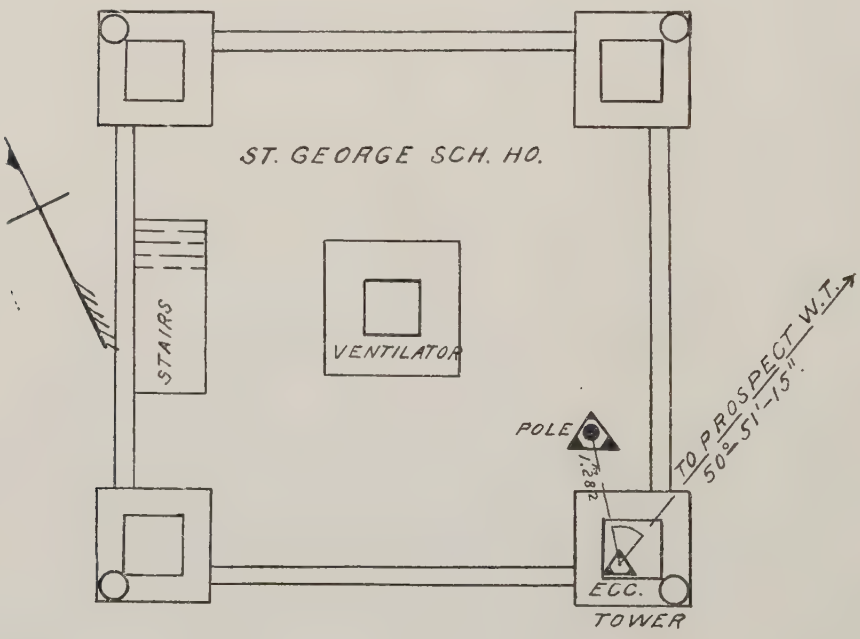
ST. GEORGE SCHOOLHOUSE.

This station is the flagpole of the Curtis High School, which is located at corner of St. Mark's place and Hamilton avenue, St. George, Borough of Richmond, New York City, N. Y.

It is reached by Staten Island ferry to St. George, thence by Shore Line trolley to Hamilton avenue and then up Hamilton avenue to St. Marks place to school.

As the tower upon which the pole is placed is surrounded by a 12-foot wall with a narrow beveled top, observations had to be taken from the top of the parapet at corner of tower near the pole. But as this parapet was very small and hollow, observing was very difficult owing to danger to instrument and observer, because no guard rail nor wind shield could be built. The instrument was placed upon the tripod, the feet of which were set into holes drilled into the terra cotta top of the parapet, while the observer stood upon a board laid over opening in parapet.

July 18, 1906.—Since this station was first occupied, it was struck by lightning and partly demolished. It has been repaired and the pole which marked the station was destroyed and replaced by a new one.



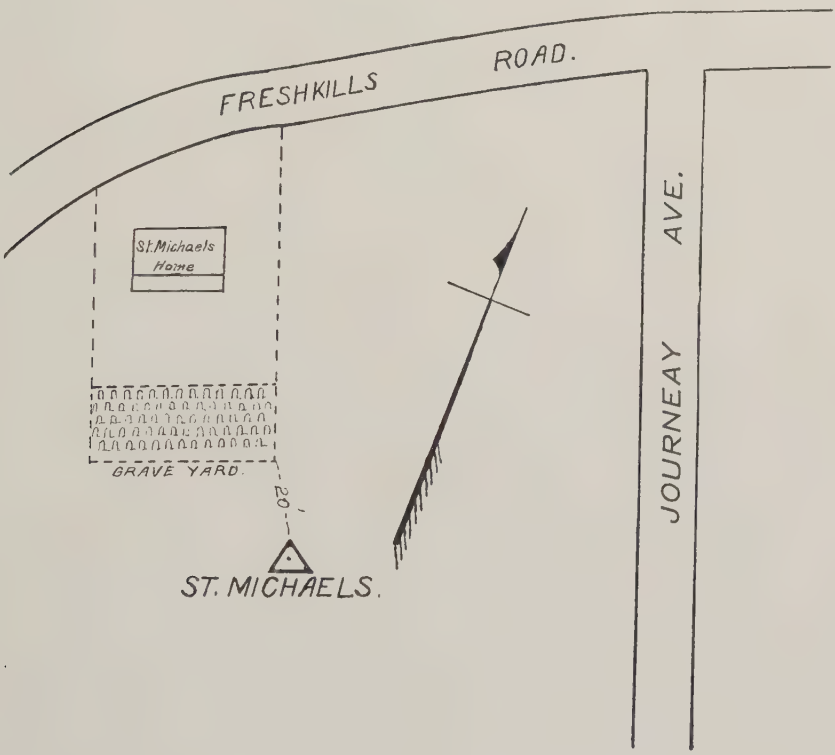
ST. MICHAELS.

This station is a 30-foot tripod and scaffold on the property of St. Michael's Home, Green Ridge, Borough of Richmond, New York City, N. Y.

The station is situated south of Freshkills road, and west of Journeay avenue and twenty feet southeast of graveyard.

The station is marked with the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′, set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Station is reached by S. I. R. T. R. R. to Annadale; thence by carriage to station.

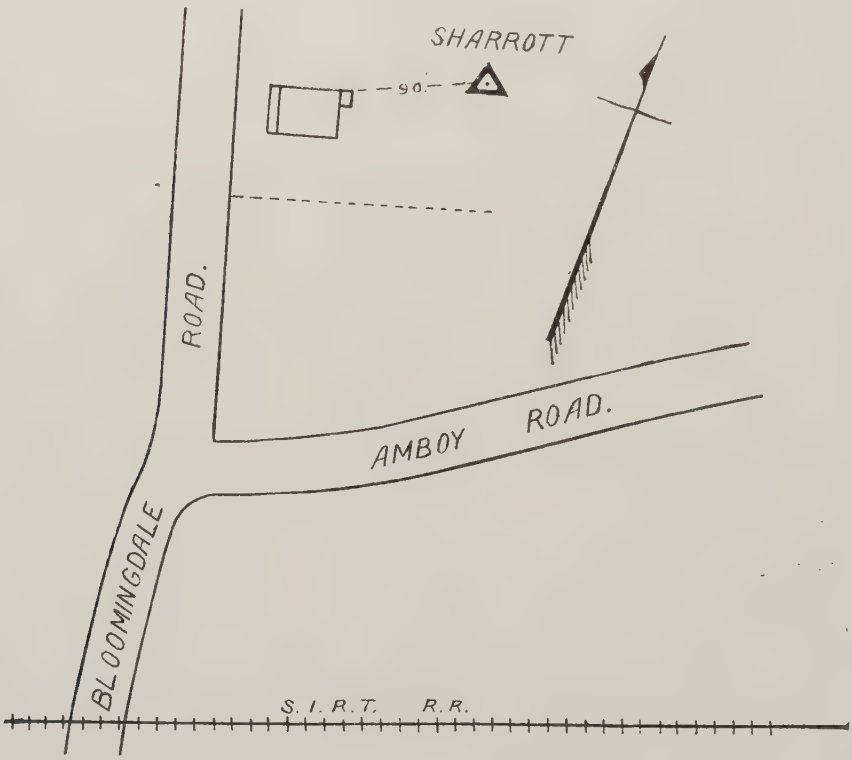


SHARROTT.

This station is a 52-foot tripod and scaffold, situated on the east side of Bloomingdale road, about 400 feet north of Amboy road, Pleasant Plains, Borough of Richmond, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt.

Reached by S. I. R. T. R. R. to Pleasant Plains; thence north on Bloomingdale road to property of Sharrott.



SNUG HARBOR CHURCH.

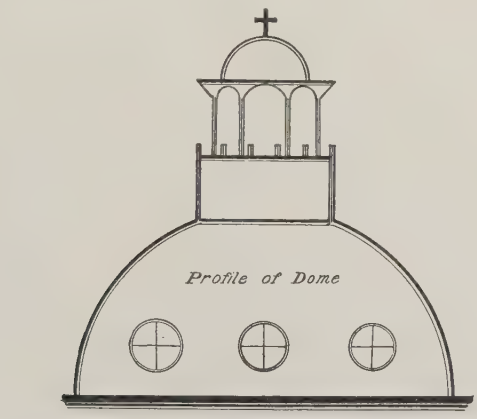
This station is the gilt cross on the dome of the Snug Harbor Church, situated on the grounds of Sailors' Snug Harbor, Borough of Richmond, New York City, N. Y.

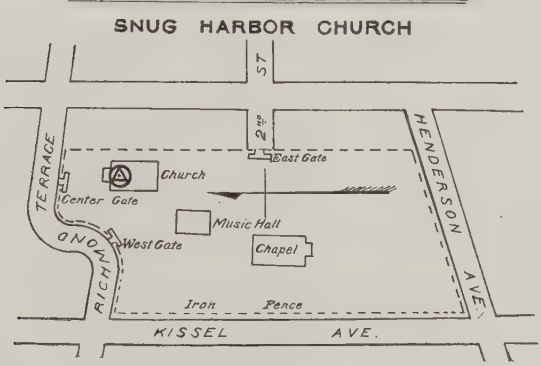
This church is built of light colored stone, with large dome, on top of which is an open tower with pillars supporting roof on which is the cross.

Prior to December, 1904, this tower was accessible for observations but in that month a fire completely gutted the building.

During the year 1906 this building was rebuilt as near to its original state as possible, but a circular sheet-iron ventilator three and one-half feet in diameter and three feet high was built in center of tower making it useless for observing purposes.

Reached by Elizabethport trolley from St. George to Sailors' Snug Harbor.





STAPLETON SCHOOLHOUSE.

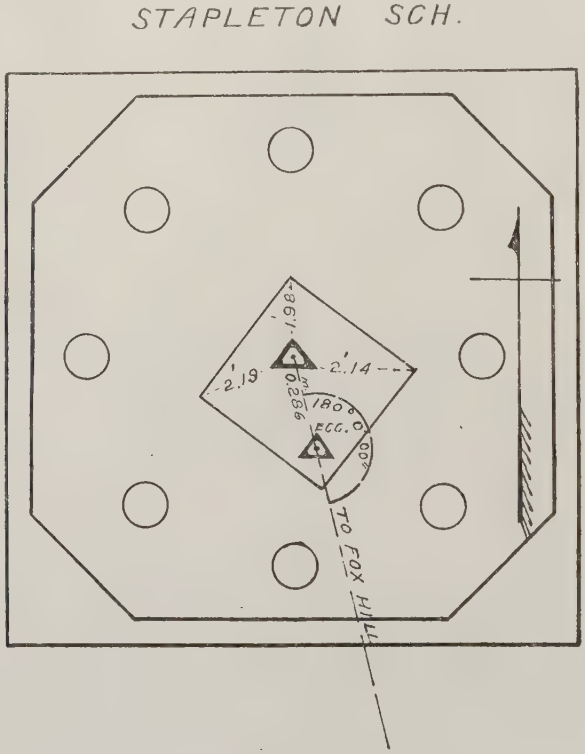
This station is the flagpole on the south tower of Stapleton School, situated on the northwest corner of Broad and Brook streets, Borough of Richmond, New York City, N. Y.

This building is three-story red brick with slate mansard roof with two open towers on the north and south ends.

The south tower was selected as station, and center of pole was dropped to floor below by means of transit, and center established on trap door. Center is marked with brass tack.

Eccentric station is 0.286 meter west of center on trap door in line with Fox Hills and is marked with brass tack.

Reached by South Beach trolley to Broad street; thence walking west to Brook street.



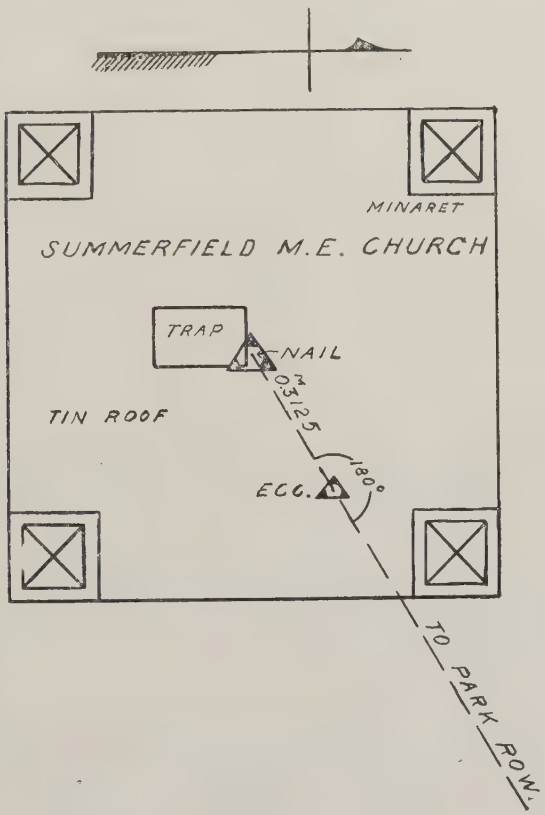
SUMMERFIELD M. E. CHURCH.

This station is the tower of the Summerfield M. E. Church on Harbor road near the S. I. R. T. R. R. at Mariner's Harbor, Borough of Richmond, New York City, N. Y.

It is reached by Staten Island R. R. at St. George ferry to Mariner's Harbor station and then walking west along tracks to Harbor road, which brings one within 100 feet of church.

The tower is wholly of wood, square in plan, with a tin roof shaped like a groined arch. On each corner is a minaret about ten feet high, all being tied together by a system of iron rods.

The station is in the center of the tower and is marked by a nail, and for a signal a heliotrope was used at the center or at an eccentric as needed.

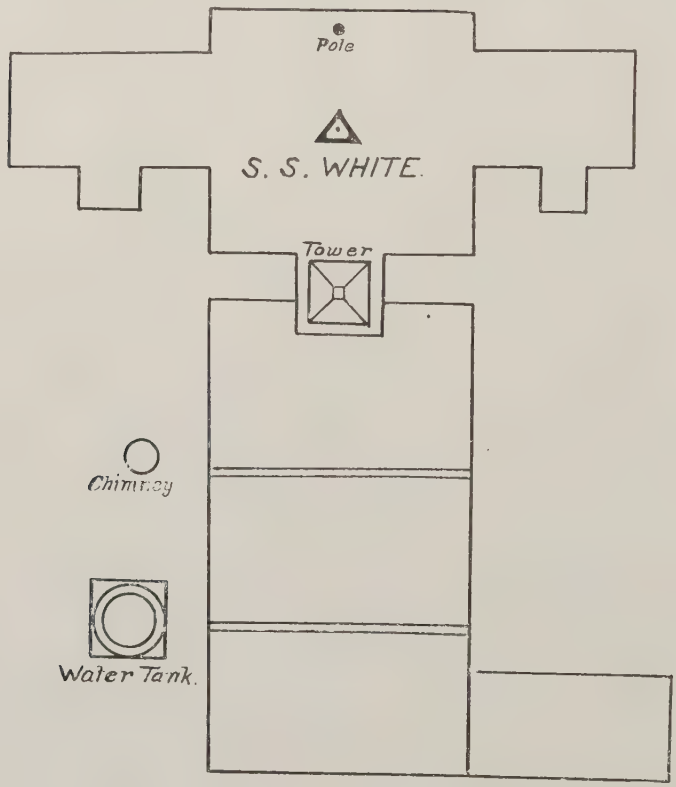


S. S. WHITE.

This station is a pole erected on the office building of the S. S. White Dental Works, located on Seguine Point on the easterly shore of Princess Bay, Borough of Richmond, New York City, N. Y.

The pole is located about half-way between the flagpole and pyramidal tower on the same building. The roof is gently sloping, tar and gravel.

Reached by S. I. R. T. R. R., Perth Amboy Division, to Princess Bay; thence by hack to S. S. White Dental Works.



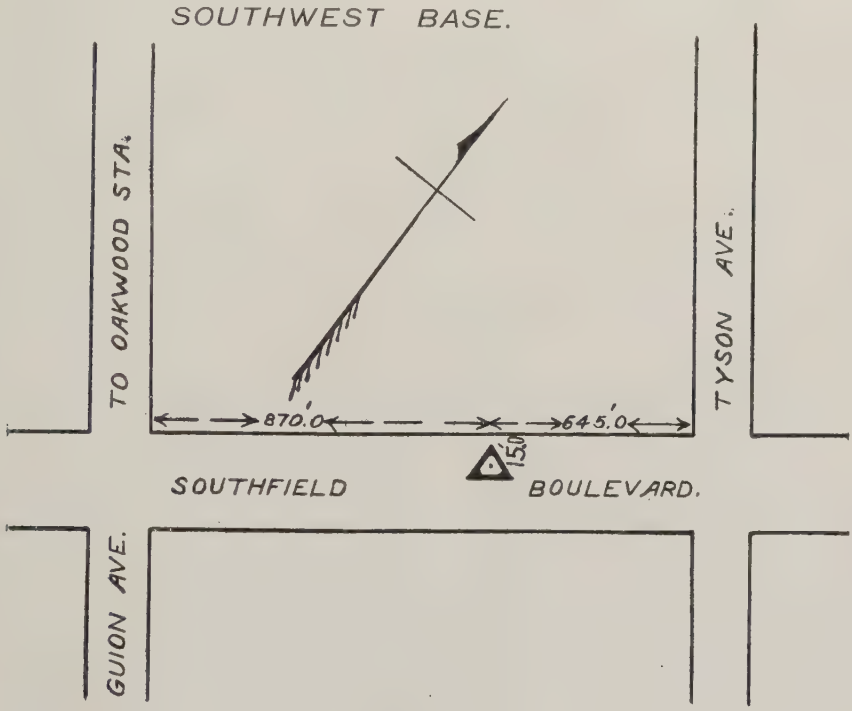
SOUTHWEST BASE.

This station is the southwest end of the proposed base line of the Borough of Richmond, New York City, N. Y.

When originally built it consisted of a 30-foot tripod and scaffold, and was observed on from Wyeth station. In September, 1906, it was rebuilt to 68 feet, thus seeing Elm Tree and Great Kills. At this height it was observed on from Great Kills, Elm Tree and Northeast Base.

The station is situated on the west side of Southfield Boulevard between Guion and Tyson avenues. It is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A small hole drilled in top of bolt marks the exact center of station.

Reached by train to Oakwood; thence walking to Southfield Boulevard.



TOTTENVILLE SCHOOLHOUSE.

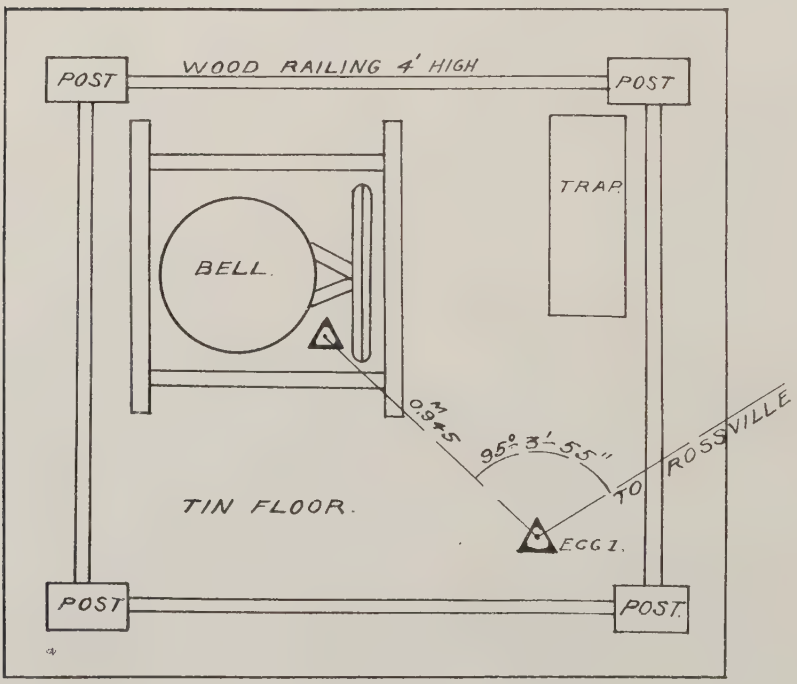
This station is the vane rod on Public School No. 1, corner Prospect avenue and Academy place, Tottenville Borough of Richmond, New York City, N. Y.

The building is two stories high, red brick, with a mansard slate roof surmounted by a square open cupola tower with a roof. This roof contains a pyramidal turret which supports the vane rod.

The point was dropped by means of a transit set up at right angles on the ground. It is marked by a brass tack driven in roof.

Reached by S. I. R. T. R. R. to Tottenville.

TOTTENVILLE SCH. HO.



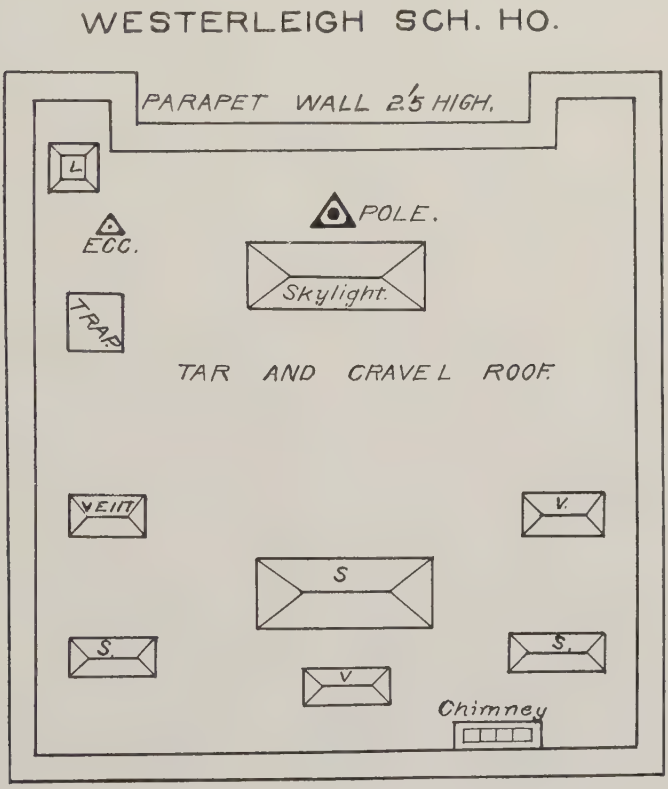
WESTERLEIGH SCHOOLHOUSE.

This station is a 15-foot tripod and scaffold erected on the roof of Westerleigh Schoolhouse situated on the Boulevard directly west of Jewett avenue, Westerleigh, Borough of Richmond, New York City, N. Y.

The feet of the tripod rested upon the same base structure as the scaffold but despite this fact it was fairly rigid.

The building is of brick with flat tar and gravel roof containing a number of white ventilators and skylights.

Reached by Silver Lake trolley from St. George to Boulevard.



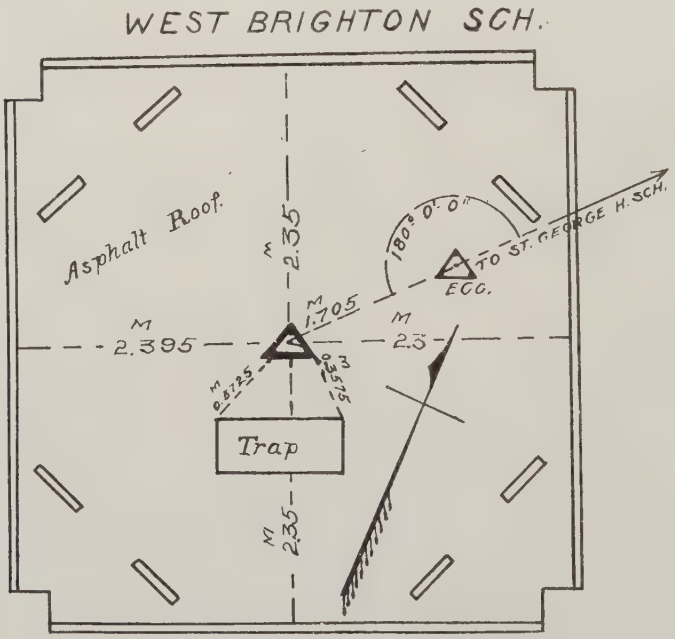
WEST BRIGHTON SCHOOLHOUSE.

This station is the weather vane on the clock tower of West Brighton School, situated on the northeast corner of Broadway and Market street, West Brighton, Borough of Richmond, New York City, N. Y.

This is a large four-story brick building with square frame clock tower with flat wooden roof covered with sheet asphalt. On this roof is a square open bell tower with eight pillars supporting dome-shaped roof, in the center of which is weather vane. The center of this weather vane was dropped to the roof of clock tower by means of transit and center established and marked with large wire nail with crosscut + thereon.

An eccentric station was established 1.705 meters northeast of center in line with St. George High School, and is marked with brass tack.

Reached by Castleton avenue trolley to Broadway; thence walking north one block to school.



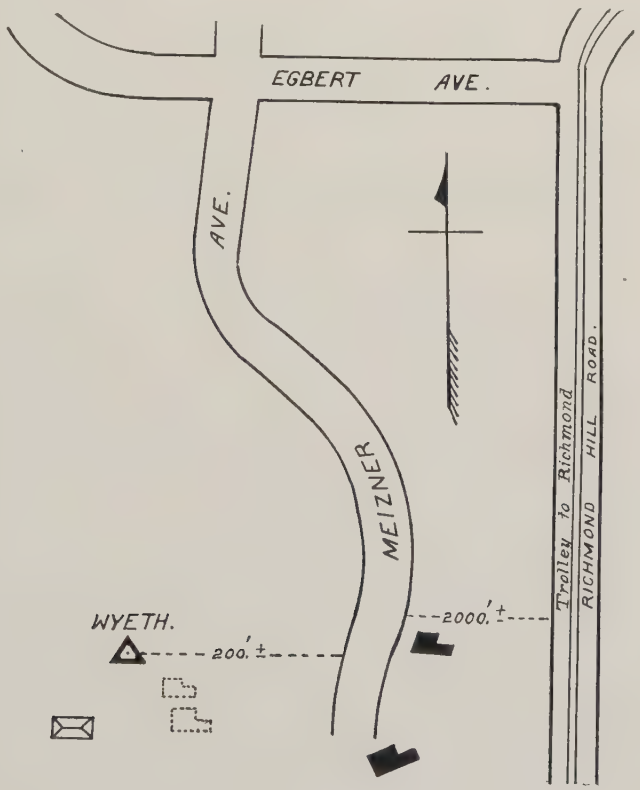
WYETH.

This station consists of an 84-foot tripod and scaffold, and is situated just north of Egbertville, Borough of Richmond, New York City, N. Y.

It is on the Suffern estate, north of the estate of Ex-Judge Wyeth.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Station is reached by trolley or train from St. George to New Dorp; thence by stage to station.



Borough of Brooklyn.

BOROUGH OF BROOKLYN.

RECTANGULAR CO-ORDINATES.

Prospect Water Tower=Origin of Axes. True Meridian at Prospect Water Tower=Axis of Ordinates.

No.	Station.	X in Meters.	X in Feet.	Y in Meters.	Y in Feet.
1	Armory, 13th Regiment	— 2455.915	— 8057.448	+ 1412.596	+ 4634.492
2	Armory, 14th Regiment	+ 1260.931	+ 4136.904	— 1194.252	— 3622.867
3	Armory, 23d Regiment	— 1206.319	— 3957.732	+ 626.393	+ 2055.091
4	Avenue U	— 3324.078	— 10905.746	— 7335.431	— 24066.326
5	Bergen Beach Casino	— 5890.362	— 19325.296	— 6046.597	— 19837.877
6	Canarsie Park	— 6401.616	— 21002.635	— 4583.666	— 15038.244
7	Canarsie Pol	— 7679.960	— 25196.669	— 5733.496	— 18810.645
8	Centennial tower	+ 651.071	+ 2136.055	— 10869.526	— 35661.103
9	Coney Island lighthouse	+ 3760.044	+ 12336.078	— 10639.930	— 34907.804
10	Church, Northeast tower	— 5168.031	— 16955.448	+ 1016.029	+ 3333.422
11	Duck Point	— 9953.797	— 32656.749	— 5631.605	— 18476.357
12	Elevator	+ 4192.005	+ 13753.270	+ 69.461	+ 227.890
13	Eppig brewery	— 2998.944	— 9839.035	+ 3151.498	+ 10339.540
14	Fort Hamilton flag staff	+ 5534.168	+ 18156.683	— 7014.216	— 23012.473

BOROUGH OF BROOKLYN.

RECTANGULAR CO-ORDINATES—*Continued.*

Prospect Water Tower = Origin of Axes. True Meridian at Prospect Water Tower = Axis of Ordinates.

No.	Station.	X in Meters.	X in Feet.	Y in Meters.	Y in Feet.
15	Inebriate asylum	+ 5822.907	+ 19103.987	— 5650.599	— 18538.673
16	Island Channel	— 6814.534	— 22357.350	— 7649.318	— 25096.137
17	Kings County asylum	— 2469.044	— 8100.522	— 1728.992	— 5672.535
18	Mill Island	— 5075.380	— 16651.476	— 7227.414	— 23711.941
19	Ocean Parkway, North base	+ 234.591	+ 769.654	— 5358.472	— 17580.253
20	Ocean Parkway, South base	— 328.929	— 1079.161	— 9258.883	— 30376.852
21	Owl Head	+ 5591.224	+ 18343.874	— 3518.449	— 11543.445
22	Prospect water tower	0.0	0.0	0.0	0.0
23	Point Breeze 3	— 4389.290	— 14400.529	— 10293.884	— 33772.517
24	Pratt institute	— 249.751	— 819.391	+ 2093.829	+ 6869.504
25	Riches Point	— 5289.557	— 17354.155	— 9019.601	— 29591.807
26	Ruffle Bar 3	— 9195.409	— 30168.604	— 8496.668	— 27876.151
27	Rugby	— 4204.366	— 13793.824	— 3050.894	— 10009.475
28	Schoolhouse, Atkins avenue	— 7457.234	— 24465.942	+ 95.167	+ 312.227
29	Schoolhouse, Barren Island	— 6811.686	— 22348.006	— 9834.216	— 32264.423

30	Schoolhouse, Bensonhurst	+ 2325.376	+ 7629.171	— 7499.848	— 24605.751
31	Schoolhouse, Blake avenue	— 4919.855	— 16141.224	— 771.536	— 2531.281
32	Schoolhouse, No. 142	+ 2894.887	+ 9497.642	+ 830.749	+ 2725.549
33	Schoolhouse, No. 143	— 1101.436	— 3613.628	+ 4756.300	+ 15604.627
34	Schoolhouse, Avenue K	— 2422.980	— 7949.393	— 5172.579	— 16970.369
35	Schoolhouse, Avenue C	— 130.323	— 427.568	— 3490.001	— 11450.111
36	Schoolhouse, 41st street	+ 3382.657	+ 11097.934	— 2270.123	— 7447.895
37	Schoolhouse, 44th street	+ 2199.584	+ 7216.468	— 3512.220	— 11523.008
38	Schoolhouse, 60th street	+ 4366.346	+ 14325.253	— 3449.750	— 11318.055
39	Schoolhouse, 79th street	+ 4336.229	+ 14226.444	— 5399.045	— 17713.367
40	Standish Arms	+ 2476.453	+ 8124.829	+ 2777.296	+ 9111.845
41	Section stone I., Ocean Parkway base	+ 90.764	+ 297.782	— 6353.970	— 20846.316
42	Section stone II., Ocean Parkway base	— 53.062	— 174.088	— 7349.466	— 24112.373
43	Section stone III., Ocean Parkway base	— 196.875	— 645.914	— 8344.873	— 27378.137
44	Smith & Gray tower	+ 1164.423	+ 3820.278	+ 1795.424	+ 5890.487

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
1	Armory, 13th Regiment.	40	41	06.503	200^{m}.6	73	56	19.255	452^{m}.1
					658^{ft}.1				1483^{ft}.3
2	Armory, 14th Regiment.	40	39	44.919	1385^{m}.6	73	58	57.520	1351^{m}.1
					4545^{ft}.9				4432^{ft}.7
3	Armory, 23d Regiment.	40	40	41.025	1265^{m}.4	73	57	12.475	293^{m}.0
					4151^{ft}.6				961^{ft}.3

BROOKLYN.

POSITIONS.

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
57 50 32.06	237 49 57.37	23d Regiment armory...	1476^{m}.35	3.1691888
			4843^{ft}.66	
107 19 44.20	287 09 42.95	Pratt Institute.....	2308^{m}.95	3.3634140
			7575^{ft}.28	
197 21 41.99	17 21 57.08	Eppig brewery.....	1821^{m}.72	3.2604817
			5976^{ft}.76	
278 20 15.99	98 21 31.25	Church, Northeast tower	2740^{m}.93	3.4379024
			8992^{ft}.63	
311 34 26.19	131 35 34.54	Blake avenue schoolhouse.....	3292^{m}.63	3.5175432
			10802^{ft}.57	
359 46 46.13	179 46 46.45	Kings County asylum...	3141^{m}.61	3.4971529
			10307^{ft}.10	
61 12 06.66	241 11 07.81	Schoolhouse, 41st street..	2420^{m}.95	3.3839850
			7942^{ft}.73	
111 48 47.91	291 47 26.57	Elevator	3157^{m}.34	3.4993215
			10358^{ft}.71	
139 48 42.47	319 47 57.11	Schoolhouse, No. 142....	2532^{m}.60	3.4035660
			8309^{ft}.04	
181 53 47.51	1 53 50.17	Smith & Gray tower....	2901^{m}.28	3.4625900
			9518^{ft}.62	
228 46 48.84	48 47 23.82	Prospect water tower....	1676^{m}.10	3.2243006
			5499^{ft}.00	
329 44 29.71	149 45 08.28	Avenue C schoolhouse..	2761^{m}.77	3.4411877
			9060^{ft}.91	
290 38 15.75	110 39 58.78	Blake avenue schoolhouse.....	3967^{m}.94	3.5985651
			13018^{ft}.15	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
3	Armory, 23d Regiment—*Continued.*				
4	Avenue U.....	40 36 22.887	706^{m}.0 2316^{ft}.3	73 55 42.451	998^{m}.0 3274^{ft}.3
5	Bergen Beach casino...	40 37 04.619	142^{m}.5 467^{ft}.5	73 53 53.250	1251^{m}.7 4106^{ft}.6

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithm
°	′	″	°	′	″			
331	48	48.52	151	49	23.53	Kings County asylum...	2672^{m}.51	3.4269194
							8768^{ft}.06	
62	34	05.81	242	33	32.33	Prospect water tower....	1359^{m}.25	3.1333009
							4459^{ft}.47	
48	23	12.91	228	21	22.90	Centennial tower	5318^{m}.99	3.7258292
							17450^{ft}.72	
57	19	02.57	237	17	39.66	Ocean Parkway, South base.....	3559^{m}.58	3.5513986
							11678^{ft}.39	
119	04	45.10	299	03	06.56	Ocean Parkway, North base.....	4070^{m}.93	3.6096939
							13356^{ft}.04	
157	24	27.70	337	24	02.76	Avenue K schoolhouse..	2343^{m}.05	3.3697821
							7687^{ft}.16	
228	13	27.59	48	14	52.88	Canarsie Park.....	4128^{m}.37	3.6157782
							13544^{ft}.49	
53	38	39.80	233	35	38.72	Centennial tower.....	8127^{m}.17	3.9099395
							26663^{ft}.89	
63	22	44.03	243	21	32.95	Avenue U.....	2871^{m}.74	3.4581448
							9421^{ft}.70	
135	47	42.73	315	44	59.50	Prospect water tower ...	8441^{m}.43	3.9264159
							27694^{ft}.92	
199	18	30.06	19	18	44.25	Canarsie Park.....	1549^{m}.69	3.1902460
							5084^{ft}.27	
264	12	50.39	84	14	42.95	Duck Point	4084^{m}.57	3.6111462
							13400^{ft}.79	
300	36	37.79	120	39	30.03	Seaside Hotel.....	7232^{m}.21	3.8592709
							23727^{ft}.68	
306	35	43.19	126	37	14.62	Ruffle Bar 3.....	4114^{m}.14	3.6142791
							13497^{ft}.81	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
6	Canarsie Park.....	40 37 52.033	1605^{m}.0 5265^{ft}.7	73 53 31.447	739^{m}.0 2424^{ft}.5
7	Canarsie Pol.....	40 37 14.717½	453^{m}.9 1489^{ft}.2	73 52 37.103	872^{m}.1 2861^{ft}.2
8	Centennial tower.....	40 34 28.337	874^{m}.1 2867^{ft}.8	73 58 31.521	741^{m}.4 2432^{ft}.4

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
48	20	22.41	228	17	07.12	Centennial tower	9447m.35	3.9753099
							30995ft.18	
52	27	26.88	232	24	38.69	Ocean Parkway, South base	7663m.89	3.8844490
							25143ft.95	
81	37	46.62	261	35	56.39	Avenue K schoolhouse	4021m.99	3.6044405
							13195ft.48	
125	39	09.39	305	36	11.94	Prospect water tower	7873m.42	3.8961632
							25831ft.38	
181	42	47.35	1	42	52.84	Ridgewood gate house	6615m.28	3.8205482
							21703ft.63	
312	00	55.44	132	03	33.51	Seaside Hotel	7687m.61	3.8857915
							25221ft.77	
12	00	50.95	192	00	26.80	Barren Island schoolhouse	4191m.63	3.6223829
							13752ft.04	
69	52	03 05	249	50	02.40	Avenue U	4641m.11	3.6666215
							15226ft.71	
132	01	46.12	312	01	10.73	Canarsie Park	1719m.38	3.2353724
							5641ft.00	
267	29	36.21	87	30	39.20	Duck Point	2276m.12	3.3571946
							7467ft.57	
331	19	00.39	151	19	42.26	Ruffle Bar 3	3151m.46	3.4985117
							10339ft.41	
10	21	17.96	190	20	14.83	Sandy Hook lighthouse	12735m.54	4.1050173
							41783ft.18	
115	48	55.09	295	45	45.16	Fort Tompkins 2	7623m.90	3.8821771
							25012ft.74	

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
9	Coney Island lighthouse	40	34	35.751	$1102^{m}.7$	74	00	43.704	$1028^{m}.0$
					$3617^{ft}.8$				$3372^{ft}.7$
10	Church N. E. tower....	40	40	53.602	$1653^{m}.4$	73	54	23.771	$558^{m}.3$
					$5424^{ft}.7$				$1831^{ft}.7$
11	Duck Point.....	40	37	17.933	$553^{m}.2$	73	51	00.359	$8^{m}.4$
					$1815^{ft}.0$				$27^{ft}.6$

BROOKLYN.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
129 26 24.67	309 24 49.74	Fort Tompkins 2	4862^{m}.62	3.6868707
			15953^{ft}.45	
204 31 34.62	24 32 14.28	Bensonhurst schoolhouse	3452^{m}.29	3.5381078
			11326^{ft}.39	
251 18 31.97	71 20 25.07	Ocean Parkway, South base	4315^{m}.90	3.6350710
			14159^{ft}.75	
274 11 41.62	94 13 07.60	Centennial tower	3117^{m}.44	3.4937980
			10227^{ft}.80	
44 33 19.36	224 32 04.43	Kings County asylum	3849^{m}.63	3.5854195
			12629^{ft}.99	
78 55 02.66	258 52 39.22	Prospect water tower	5266^{m}.96	3.7215599
			17280^{ft}.02	
208 47 23.65	28 48 14.04	Lutheran Cemetery church	3765^{m}.93	3.5758722
			12355^{ft}.39	
234 38 59.25	54 39 38.86	Ridgewood gate house	1748^{m}.79	3.2427376
			5737^{ft}.49	
347 36 58.65	167 37 32.74	Canarsie Park	5733^{m}.96	3.7584549
			18812^{ft}.17	
333 12 37.85	152 13 37.57	Seaside Hotel	4629^{m}.53	3.6655370
			15188^{ft}.72	
14 54 10.42	194 53 49.32	Ruffle Bar 3	2963^{m}.74	3.4718397
			9723 ^{ft}.54	
36 51 37.71	216 50 10.60	Barren Island schoolhouse	5247^{m}.36	3.7199405
			17215^{ft}.71	
75 39 49.19	255 36 45.56	Avenue U	6845^{m}.16	3.8353833
			22457^{ft}.83	

No.	Stations.	Latitude. ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
11	Duck Point—*Continued.*				
12	Elevator	40 40 22.934	707m.4	74 01 02.326	54m.6
			2320ft.9		179ft.1
13	Eppig brewery	40 42 02.870	88m.5	73 55 56.100	1317m.0
			290ft.4		4320ft.9
14	Fort Hamilton flag staff	40 36 33.259	1025m.9	74 01 59.248	1392m.9
			3365ft.8		4569ft.9

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
106	30	48.06	286	29	09.68	Canarsie Park	3703^{m}.53	3.5686163
							12150^{ft}.66	
21	16	21.16	201	15	42.42	Owl Head	3851^{m}.09	3.5855840
							12634^{ft}.78	
190	19	49.61	10	20	11.15	Park Row building	4326^{m}.17	3.6361039
							14193^{ft}.44	
270	55	01.13	90	56	57.46	Prospect water tower	4192^{m}.58	3.6224814
							13755^{ft}.16	
330	52	52.80	150	53	48.08	Schoolhouse, 44th street	4098^{m}.56	3.6126311
							13446^{ft}.69	
253	41	35.63	73	43	26.23	Lutheran Cemetery church	4147^{m}.79	3.6178164
							13608^{ft}.21	
287	22	01.92	107	23	41.73	Ridgewood gate house	3765^{m} 98	3.5758782
							12355^{ft}.55	
314	34	32.33	134	35	32.51	Church, Northeast tower	3043^{m}.87	3.4834264
							9986^{ft}.43	
35	23	41.58	215	22	51.79	Armory, 23d Regiment	3096^{m}.72	3.4909020
							10159^{ft}.82	
43	36	08.22	223	34	44.93	Prospect water tower	4350^{m}.36	3.6385249
							14272^{ft}.81	
68	58	49.51	248	57	33.16	Pratt Institute	2945^{m}.63	3.4691781
							9664^{ft}.12	
278	33	48.59	98	35	17.43	Bensonhurst schoolhouse	3245^{m}.33	3.5112593
							10647^{ft}.39	
290	54	23.85	110	57	06.15	Ocean Parkway, South base	6278^{m}.09	3.7978277
							20597^{ft}.37	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
14	Fort Hamilton flag staff	—*Continued.*			
15	Inebriate asylum.....	40 37 17.459	538^{m}.5 1766^{ft}.7	74 02 11.574	272^{m}.0 892^{ft}.4
16	Island Channel.....	40 36 12.634	389^{m}.7 1278^{ft}.5	73 53 13.997	329^{m}.1 1079^{ft}.7

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
308	14	57.52	128	17	12.68	Centennial tower.....	6221^{m}.58	3.7939007
							20411^{ft}.97	
333	53	02.72	153	53	51.87	Coney Island lighthouse	4036^{m}.49	3.6060039
							13243^{ft}.05	
74	50	31.73	254	49	36.93	Fort Tompkins 2.....	2050^{m}.61	3.3118827
							6727^{ft}.71	
213	27	08.84	33	27	49.16	Schoolhouse, 60th street.	2639^{m}.19	3.4214703
							8658^{ft}.74	
260	21	04.65	80	21	45.83	Schoolhouse, 79th street.	1507^{m}.81	3.1783458
							4946^{ft}.87	
297	49	18.92	117	50	55.80	Bensonhurst schoolhouse	3956^{m}.31	3.5972907
							12979^{ft}.99	
41	38	52.89	221	38	06.12	Fort Tompkins 2.....	2542^{m}.23	3.4052141
							8340^{ft}.63	
124	32	15.34	304	30	29.15	St. George schoolhouse..	4651^{m}.17	3.6675623
							15259^{ft}.71	
0	07	37.26	180	07	37.12	Barren Island schoolhouse.....	2184^{m}.90	3.3394307
							7168^{ft}.29	
95	11	28.31	275	09	51.69	Avenue U.....	3504^{m}.54	3.5446309
							11497^{ft}.81	
172	22	52.89	352	22	41.53	Canarsie Park.....	3093^{m}.34	3.4904271
							10148^{ft}.73	
237	19	19.84	57	20	46.83	Duck Point.....	3731^{m}.77	3.5719153
							12243^{ft}.32	
289	38	34.95	109	39	40.82	Ruffle Bar 3.....	2527 .17	3.4026336
							8291 .22	

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
17	Kings County asylum..	40	39	24.655	$760^{m}.5$	73	56	18.741	$440^{m}.3$
					$2495^{ft}.1$				$1444^{ft}.6$
18	Mill Island	40	36	26.357	$813^{m}.0$	73	54	27.956	$657^{m}.2$
					$2667^{ft}.3$				$2156^{ft}.2$
19	Ocean Parkway, North base.....	40	37	27.003	$832^{m}.9$	73	58	13.822	$324^{m}.9$
					$2732^{ft}.6$				$1065^{ft}.9$

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
0	47	07.50	180	47	06.20	Avenue K schoolhouse..	3443^{m}.90	3.5370499
							11298^{ft}.86	
36	42	06.56	216	40	51.61	Ocean Parkway, North base.....	4525^{m}.79	3.6556944
							14848^{ft}.36	
53	02	24.09	233	01	19.24	Avenue C schoolhouse..	2927^{m}.59	3.4665100
							9604^{ft}.93	
69	06	51.06	249	04	41.62	Schoolhouse, 44th street.	4997^{m}.60	3.6987616
							16396^{ft}.29	
125	01	16.80	305	00	08.33	Prospect water tower ...	3014^{m}.23	3.4791767
							9889^{ft}.19	
86	30	35.65	266	29	47.17	Avenue U.....	1754^{m}.63	3.2441849
							5756^{ft}.65	
206	40	46.93	26	41	23.72	Canarsie Park.....	2957^{m}.75	3.4709620
							9703^{ft}.88	
287	09	41.54	107	11	35.55	Ruffle Bar 3.....	4311^{m}.11	3.6345887
							14144^{ft}.03	
326	22	21.68	146	23	09.67	Barren Island schoolhouse.....	3132^{m}.12	3.4958381
							10275^{ft}.96	
4	19	11.72	184	19	00.19	Centennial tower	5526^{m}.77	3.7424716
							18132^{ft}.41	
73	15	02.27	253	11	40.72	Fort Tompkins 2.....	7601^{m}.68	3.8809094
							24939^{ft}.84	
182	30	17.91	2	30	24.41	Prospect water tower ...	5363^{m}.60	3.7294567
							17597^{ft}.08	
235	59	49.17	86	01	02.79	Avenue K schoolhouse..	2664^{m}.06	3.4255447
							8740^{ft}.34	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
20	Ocean Parkway, South base.....	40 35 20.554	634m.0 2080ft.0	73 57 49.853	1172m.3 3846ft.1
21	Owl Head.....	40 38 26.588	820m.1 2690ft.6	74 02 01.786	42m.0 137ft.8
22	Prospect water tower..	40 40 20.721	639m.2 2097ft.1	73 58 03.841	90m.2 295ft.9

BROOKLYN.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
31 19 15.81	211 18 48.70	Centennial tower.....	1885m.36	3.2753937
			6185ft.55	
102 18 07.81	282 14 30.73	Fort Tompkins 2.....	8027m.01	3.9045536
			26335ft.28	
171 46 53.37	351 46 37.77	Ocean Parkway, North base.....	3940m.9117	3.5955967
			12929ft.4743	
177 58 04.47	357 57 55.36	Prospect water tower...	9264m.72	3.9668325
			30396ft.00	
207 08 08.37	27 09 06.36	Avenue K schoolhouse..	4591m.62	3.6619656
			15064ft.34	
25 27 32.08	205 26 38.92	Fort Tompkins 2.....	4665m.56	3.6498759
			15306ft.92	
66 23 46.92	246 21 35.43	Kendall.....	5178m.89	3.7142565
			16991ft.07	
97 05 04.25	277 03 11.65	St. George schoolhouse.	4092m.67	3.6120065
			13427ft.37	
195 28 18.90	15 29 19.19	Park Row building.....	8140m.14	3.9106319
			26706ft.44	
237 46 31.88	57 49 06.90	Prospect water tower...	6606m.15	3.8199487
			21673ft.68	
326 14 25.07	146 14 59.86	Schoolhouse, 79th street.	2260m.89	3.3542803
			7417ft.60	
3 25 40.26	183 25 22.24	Centennial tower.....	10889m.01	4.0369883
			35725ft.03	
44 51 59.39	224 48 31.25	Fort Tompkins 2.....	10651m.01	4.0273910
			34944ft.19	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
23	Point Breeze 3.....	40 34 46.957	1448^{m}.4 4752^{ft}.0	73 54 57.217	1345^{m}.7 4415^{ft}.0
24	Pratt Institute.....	40 41 28.601	882^{m}.2 2894^{ft}.4	73 57 53.204	1249^{m}.2 4098^{ft}.4
25	Riches Point.....	40 35 28.251	871^{m}.4 2858^{ft}.9	73 54 18.900	444^{m}.4 1458^{ft}.0

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
83	31	06.21	263	28	46.80	Centennial tower.....	5073^{m}.12	3.7052752
							16644^{ft}.06	
160	13	55.59	340	13	26.15	Avenue U.....	3144^{m}.38	3.4975356
							10316^{ft}.19	
199	26	47.95	19	27	43.77	Canarsie Park.....	6054^{m}.42	3.7820728
							19863^{ft}.54	
259	17	20.84	79	18	27.85	Barren Island school-house.....	2465^{m}.63	3.3919273
							8089^{ft}.32	
340	38	10.71	160	38	30.38	Rockaway Point.....	2145^{m}.70	3.3315700
							7039^{ft}.68	
326	54	11.10	146	54	37.65	Armory, 23d Regiment..	1751^{m}.68	3.2434557
							5746^{ft}.97	
6	48	14.40	186	48	07.47	Prospect water tower....	2108^{m}.67	3.3240090
							6918^{ft}.19	
121	20	41.33	301	18	59.55	Park Row building.....	4289^{m}.54	3.6324104
							14073^{ft}.27	
3	17	48.44	183	17	43.20	Rockaway Point	3303^{m}.52	3.5189776
							10838^{ft}.30	
35	16	53.32	215	16	28.40	Point Breeze 3.....	1560^{m}.22	3.1931853
							5118^{ft}.82	
130	37	59.91	310	37	05.54	Avenue U.....	2588^{m}.35	3.4130227
							8491^{ft}.94	
194	06	51.61	14	07	22.50	Canarsie Park.....	4573^{m}.20	3.6602205
							15003^{ft}.91	
262	24	54.18	82	26	42.28	Ruffle Bar 3.....	3940^{m}.70	3.5955736
							12928^{ft}.78	
298	11	43.48	118	12	25.57	Barren Island school-house.....	1726^{m}.41	3.2371428
							5664^{ft}.06	

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
26	Ruffle Bar 3	40	35	45.081	1390^{m}.6	73	51	32.775	770^{m}.6
					4562^{ft}.3				2528^{ft}.2
27	Rugby.....	40	38	41.775	1288^{m}.6	73	55	04.905	115^{m}.2
					4227^{ft}.7				378^{ft}.0
28	Schoolhouse, Atkins avenue.....	40	40	23.685	730^{m}.6	73	52	46.330	1088^{m}.2
					2397^{ft}.0				3570^{ft}.2

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
60	46	23.65	240	45	17.65	Barren Island schoolhouse	2733^{m}.34	3.4366933
							8967^{ft}.63	
101	15	30.41	281	12	47.92	Avenue U	5985^{m}.06	3.7770687
							19635^{ft}.98	
144	32	41.25	324	31	24.00	Canarsie Park	4808^{m}.00	3.6819644
							15774^{ft}.25	
292	51	28.69	112	52	49.49	Seaside Hotel	3169^{m}.65	3.5010120
							10399^{ft}.09	
40	02	58.23	220	02	08.84	Avenue K schoolhouse	2770^{m}.36	3.4425359
							9089^{ft}.09	
83	52	50.49	263	50	57.55	Avenue C schoolhouse	4097^{m}.64	3.6125338
							13443^{ft}.67	
127	19	52.11	307	19	04.00	Kings County asylum	2181^{m}.46	3.3387472
							7157^{ft}.01	
304	55	53.47	124	56	54.34	Canarsie Park	2679^{m}.05	3.4279809
							8789^{ft}.52	
12	46	16.89	192	45	47.50	Canarsie Park	4796^{m}.44	3.6809190
							15736^{ft}.32	
71	11	54.77	251	10	44.36	Blake avenue schoolhouse	2681^{m}.32	3.4283482
							8796^{ft}.96	
111	58	13.93	291	57	10.43	Church, Northeast tower	2467^{m}.47	3.3922520
							8095^{ft}.36	
155	59	33.95	335	59	10.04	Ridgewood gate house	2117^{m}.71	3.3258665
							6947^{ft}.85	
208	52	27.85	28	53	08.58	Forest Park	3037^{m}.78	3.4825559
							9966^{ft} 45	
317	19	33.06	137	20	31.82	Spring creek	3125^{m}.67	3.4949436
							10254^{ft}.80	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
29	Schoolhouse, Barren Island	40 35 01.801	$55^{m}.5$	73 53 14.203	$234^{m}.0$
			$182^{ft}.1$		$1095^{ft}.8$
30	Schoolhouse, Bensonhurst	40 36 17.570	$542^{m}.0$	73 59 42.749	$1005^{m}.1$
			$1778^{ft}.2$		$3297^{ft}.6$
31	Schoolhouse, Blake avenue	40 39 55.656	$1716^{m}.7$	73 54 34.390	$807^{m}.8$
			$5632^{ft}.2$		$2650^{ft}.3$

BROOKLYN.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
82 09 14.66	262 05 48.25	Centennial tower	7534^{m}.22	3.8770385
			24718^{ft}.52	
95 07 26.23	275 04 26.89	Ocean Parkway, South base	6508^{m}.23	3.8134630
			21352^{ft}.42	
125 40 23.14	305 38 46.68	Avenue U	4290^{m}.38	3.6324955
			14076^{ft}.02	
136 46 47.05	316 44 45.64	Avenue K schoolhouse	6402^{m}.47	3.8063476
			21005^{ft}.44	
145 20 38.08	325 17 29.49	Prospect water tower	11962^{m}.90	4.0778363
			39248^{ft}.28	
175 35 11.78	355 35 00.56	Canarsie Park	5266^{m}.54	3.7215250
			17278^{ft}.64	
268 51 56.87	88 54 23.65	Seaside Hotel	5307^{m}.12	3.7248589
			17411^{ft}.78	
89 26 24.15	269 24 00.52	Fort Tompkins 2	5188^{m}.69	3.7150576
			17023^{ft}.23	
224 17 50.03	44 18 47.93	Ocean Parkway, North base	2992^{m}.80	3.4760783
			9818^{ft}.88	
243 52 18.04	63 54 29.54	Avenue K schoolhouse	5288^{m}.01	3.7232923
			17349^{ft}.08	
303 30 53.97	123 32 07.44	Ocean Parkway, South base	3184^{m}.26	3.5030092
			10447^{ft}.03	
333 33 38.09	153 34 24.43	Centennial tower	3762^{m}.72	3.5755016
			12344^{ft}.86	
17 27 53.85	197 27 33.96	Rugby	2389^{m}.02	3.3782189
			7837^{ft}.98	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
31	Schoolhouse Blake avenue—*Continued.*				
32	Schoolhouse No. 142...	40 40 47.635	1469^{m}.3 4820^{ft}.5	74 00 07.111	167^{m}.0 547^{ft}.9
33	Schoolhouse No. 143...	40 42 54.913	1693^{m}.8 5557^{ft}.1	73 57 16.915	397^{m}.0 1302^{ft}.5

BROOKLYN.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
68 41 55.91	248 40 47.90	Kings County asylum	2631^{m}.20	3.4201533
			8632^{ft}.53	
98 57 01.81	278 54 45.31	Prospect water tower	4979^{m}.98	3.6972279
			16338^{ft}.48	
187 56 31.56	7 56 38.47	Church, Northeast tower	1804^{m}.71	3.2564076
			5920^{ft}.95	
338 47 49.07	158 48 30.07	Canarsie Park	4089^{m}.98	3.6117215
			13418^{ft}.54	
59 34 07.33	239 33 31.34	Elevator	1504^{m}.02	3.1772532
			4934^{ft}.44	
171 31 50.44	351 31 35.98	Park Row building	3532^{m}.64	3.5480995
			11590^{ft}.00	
192 06 34.38	12 06 45.98	Standish Arms	1991^{m}.01	3.2990741
			6532^{ft}.17	
240 50 22.31	60 51 10.33	Smith & Gray tower	1981^{m}.19	3.2969261
			6499^{ft}.95	
272 49 49.01	92 51 42.83	23d Regiment armory	4106^{m}.30	3.6134505
			13472^{ft}.09	
285 59 22.63	106 00 42.98	Prospect water tower	3011^{m}.73	3.4788160
			9880^{ft}.98	
235 36 25.35	55 38 16.36	Consumers brewery	4830^{m}.05	3.6839515
			15846^{ft}.59	
310 13 52.03	130 14 44.73	Eppig brewery	2485^{m}.14	3.3953513
			8153^{ft}.33	
337 57 23.31	157 58 00.91	13th Regiment armory	3607^{m}.63	3.5572218
			11836^{ft}.03	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
33	Schoolhouse No. 143—*Continued.*				
34	Schoolhouse, Avenue K	40 37 33.017	1018^{m}.4 3341^{ft}.2	73 56 20.749	487^{m}.7 1600^{ft}.1
35	Schoolhouse, Avenue C.	40 38 27.578	850^{m}.6 2790^{ft}.7	73 57 58.295	1369^{m}.8 4494^{ft}.1

BROOKLYN.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
13 02 48.82	193 02 18.21	Prospect water tower...	4882^{m}.17	3.6886126
			16017^{ft}.59	
17 44 49.94	197 44 26.27	Pratt Institute.....	2795^{m}.38	3.4464401
			9171^{ft}.18	
37 26 02.82	217 24 59.87	Smith & Gray tower....	3728^{m}.39	3.5715215
			12232^{ft}.23	
61 03 38.22	241 01 58.81	Standish Arms.....	4088^{m}.73	3.6115888
			13414^{ft}.44	
286 57 41.60	106 59 22.46	Covert avenue schoolhouse.....	3788^{m}.85	3.5785074
			12430^{ft}.59	
200 00 06.82	20 00 47.64	Long Island City High School.....	4272^{m}.04	3.6306349
			14015^{ft}.85	
28 22 11.12	208 20 46.02	Centennial tower.....	6473^{m}.41	3.8111330
			21238^{ft}.18	
76 34 08.92	256 29 33.75	Fort Tompkins 2.....	10217^{m}.01	4.0093238
			33520^{ft}.31	
154 55 08.25	334 54 01.09	Prospect water tower...	5711^{m}.95	3.7567846
			18739^{ft}.96	
6 02 43.26	186 02 21.63	Centennial tower.....	7420^{m}.78	3.8704497
			24346^{ft}.34	
11 03 06.62	191 02 56.50	Ocean Parkway, North base.....	1903^{m}.77	3.2796148
			6245^{ft}.95	
177 51 44.86	357 51 41.25	Prospect water tower ...	3492^{m}.43	3.5431281
			11458^{ft}.08	
306 16 33.33	126 17 36.85	Avenue K schoolhouse..	2843^{m}.83	3.4539029
			9330^{ft}.13	

GEOGRAPHICAL

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
36	Schoolhouse, 41st street	40	39	07.101	$219^{m}.0$	74	00	27.821	$653^{m}.7$
					$718^{ft}.5$				$2144^{ft}.7$
37	Schoolhouse, 44th street	40	38	26.847	$828^{m}.1$	73	59	37.449	$879^{m}.9$
					$2716^{ft}.9$				$2886^{ft}.8$
38	Schoolhouse, 60th street	40	38	28.842	$889^{m}.6$	74	01	09.661	$227^{m}.0$
					$2918^{ft}.6$				$744^{ft}.7$

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
60	29	52.59	240	28	51.38	Owl Head	2536^{m}.94	3.4043109
							8323^{ft}.28	
160	53	29.54	340	53	07.06	Elevator	2475^{m}.62	3.3936842
							8122^{ft}.10	
188	54	48.00	8	55	01.50	Schoolhouse No. 142	3139^{m}.00	3.4967914
							10298^{ft}.54	
236	06	29.21	56	08	03.04	Prospect water tower	4073^{m}.80	3.6099994
							13365^{ft}.46	
212	02	26.06	32	03	27.06	Prospect water tower	4144^{m}.14	3.6174340
							13596^{ft}.23	
269	26	12.09	89	27	16.67	Avenue C schoolhouse	2330^{m}.01	3.3673587
							7644^{ft}.37	
313	11	54.74	133	12	49.20	Ocean Parkway, North base	2696^{m}.27	3.4307627
							8846^{ft}.01	
1	47	23.53	181	47	20.08	Bensonhurst schoolhouse	3989^{m}.61	3.6009306
							13089^{ft}.25	
333	13	17.21	153	14	13.80	Bensonhurst schoolhouse	4535^{m}.29	3.6566049
							14879^{ft}.53	
359	04	52.70	179	04	53.57	Schoolhouse, 79th street	1949^{m}.53	3.2899293
							6396^{ft}.08	
37	29	04.65	217	27	37.56	Fort Tompkins 2	5168^{m}.17	3.7133369
							16955^{ft}.90	
86	45	22.43	266	44	48.48	Owl Head	1226^{m}.80	3.0887747
							4024^{ft}.93	
182	48	08.84	2	48	13.62	Elevator	3523^{m}.53	3.5469777
							11560^{ft}.11	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
38	Schoolhouse, 60th street	—*Continued.*			
39	Schoolhouse, 79th street	40 37 25.647	791^{m}.1 2595^{ft}.5	74 01 08.331	195^{m}.8 642^{ft}.4
40	Standish Arms	40 41 50.745	1565^{m}.2 5135^{ft}.2	73 59 49.320	1157^{m}.9 3798^{ft}.9

BROOKLYN.

POSITIONS—*Continued.*

Azimuth.	Back Azimuth.	To Stations.	Distance.	Logarithms.
° ′ ″	° ′ ″			
198 56 13.92	18 56 54.68	Schoolhouse No. 142.....	4526^{m}.35	3.6557483
			14850^{ft}.20	
219 47 27.73	39 47 54.99	Schoolhouse, 41st street..	1535^{m}.96	3.1863791
			5039^{ft}.23	
218 44 10.38	38 46 10.57	Prospect water tower....	6924^{m}.78	3.8404060
			22719^{ft}.05	
228 31 19.53	48 32 09.71	Schoolhouse, 44th street.	2850^{m}.50	3.4549213
			9352^{ft}.02	
246 49 27.64	66 51 31.40	Avenue C schoolhouse..	4857^{m}.42	3.6864059
			15936^{ft}.39	
269 23 59.56	89 25 53.18	Ocean Parkway, North base..	4101^{m}.84	3.6129787
			13457^{ft}.45	
309 34 12.60	129 36 21.79	Ocean Parkway, South base.....	6054^{m}.92	3.7821084
			19865^{ft}.18	
316 13 11.50	136 14 07.21	Bensonhurst schoolhouse	2908^{m}.08	3.4636057
			9540^{ft}.93	
36 31 48.76	216 31 15.62	Fort Hamilton flag staff.	2010^{m}.93	3.3033965
			6597^{ft}.53	
148 46 51.51	328 46 25.45	Park Row building.....	1809^{m}.49	3.2575557
			5936^{ft}.64	
284 03 18.12	104 04 33.83	Pratt Institute.....	2810^{m}.57	3.4487945
			9221^{ft}.01	
306 47 26.30	126 48 02.74	Smith & Gray tower....	1638^{m}.75	3.2145121
			5376^{ft}.47	
32 20 14.22	212 19 26.63	Elevator	3205^{m}.54	3.5059013
			10516^{ft}.84	

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
41	Ocean Parkway base, section stone I.....	40	36	54.730	1688^{m}.2	73	58	07.702	181^{m}.0
					5538^{ft}.7				593^{ft}.8
42	Ocean Parkway base, section stone II....	40	36	22.457	692^{m}.7	73	58	01.584	37^{m}.2
					2272^{ft}.6				122^{ft}.0
43	Ocean Parkway base, section stone III....	40	35	50.186	1548^{m}.0	73	57	55.468	1304^{m}.2
					5078^{ft}.7				4278^{ft}.9
44	Smith & Gray tower...	40	41	18.924	583^{m}.7	73	58	53.431	1254^{m}.6
					1915^{ft}.0				4116^{ft}.1

BROOKLYN.

POSITIONS—*Continued.*

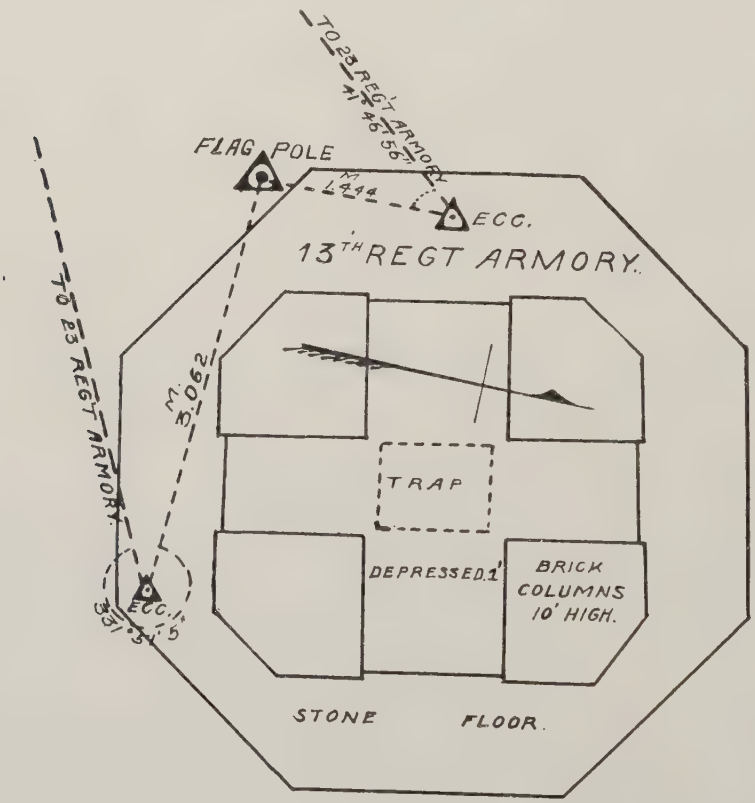
Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
171 46 41.75	351 46 37.77	Ocean Parkway, North base.....	1005^{m}.8344	3.0025265
			3299^{ft}.9751	
171 46 45.73	351 46 41.75	Ocean Parkway base, section stone I.....	1005^{m}.8319	3.0025254
			3299^{ft}.9668	
171 46 49.71	351 46 45.73	Ocean Parkway base, section stone II....	1005^{m}.7480	3.0024871
			3299^{ft}.6753	
351 46 49.71	171 46 53.37	Ocean Parkway, South base.....	928^{m}.5024	2.9654380
			3029^{ft}.8574	
258 04 32.97	78 05 12.24	Pratt Institute.....	1445^{m}.31	3.1599623
			4741^{ft}.82	
296 14 21.47	116 15 27.28	23d Regiment armory...	2643^{m}.30	3.4221470
			8672^{ft}.23	
327 01 32.11	147 02 04.44	Prospect water tower...	2139^{m}.96	3.3304057
			7020^{ft}.85	
34 11 12.53	214 08 16.65	Fort Tompkins 2.....	11297^{m}.43	4 0529798
			37064^{ft}.98	
120 18 54.16	300 15 31.37	Bergen Dutch Reformed church..	8452^{m}.91	3.9270062
			27732^{ft}.59	
138 20 49.66	318 19 47.16	Park Row building.....	3385^{m}.09	3.5295707
			11105^{ft}.92	

ARMORY, THIRTEENTH REGIMENT.

This station is the flagpole on the Thirteenth Regiment Armory, corner of Putnam and Sumner avenues, Borough of Brooklyn, New York City, N. Y.

The building is of brick with an octagonal brick tower located on the western end. The pole projects from the main building near the outside of this tower. The tower contains four brick columns, about 10 feet high, surmounted by a blue stone cap which is depressed about one foot. For this reason it was necessary to establish two eccentric stations to obtain observations on all the stations.

Reached by Lexington avenue elevated to Sumner avenue station, thence walk through Sumner avenue to Putnam avenue.



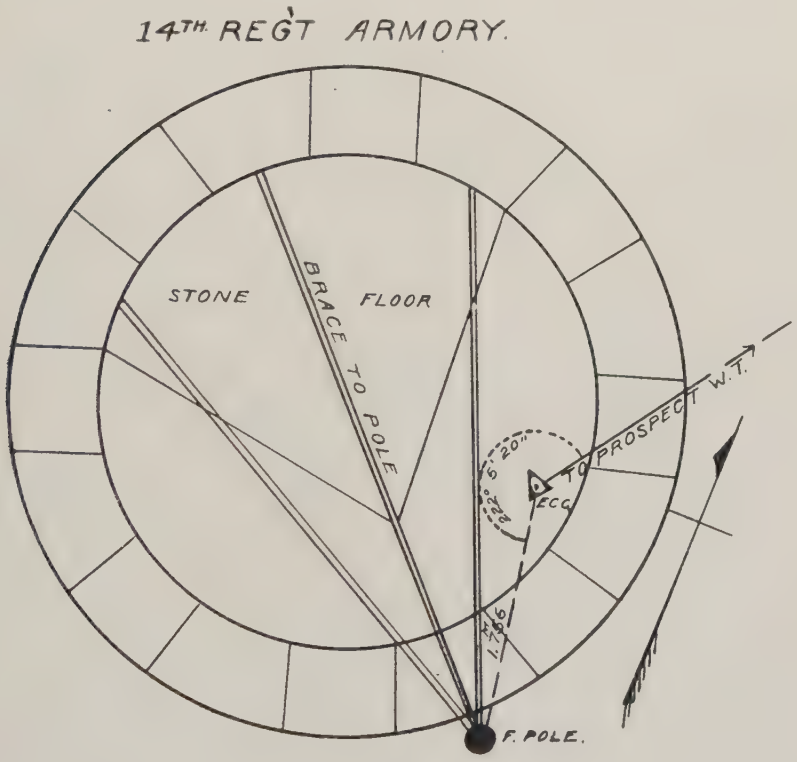
ARMORY, FOURTEENTH REGIMENT.

This station is the flagpole on the southeast corner of the Fourteenth Regiment Armory, corner Eighth avenue and Fourteenth street, Borough of Brooklyn, New York City, N. Y.

The building is of brick. The pole projects from the side of a square tower, circular at the top and ornamented by stone-capped parapet 4 feet high. The floor is of stone and has a large triangular opening.

The eccentric station was established by drilling a small hole in the stone floor and cutting a triangle around it.

Reached by Smith street trolley to Eighth avenue. Walk west to Fourteenth street.



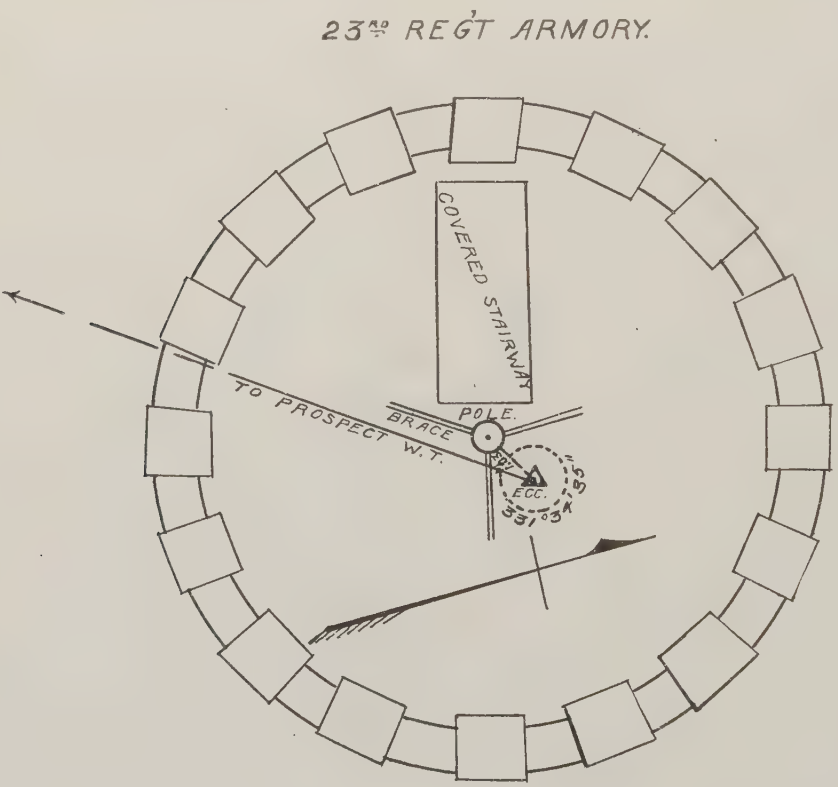
ARMORY, TWENTY-THIRD REGIMENT.

This station is the flagpole on the southeast corner of the Twenty-third Regiment Armory, Atlantic and Bedford avenues, Borough of Brooklyn, New York City, N. Y.

The building is entirely of brick. The pole is located in the center of a circular parapet tower. The floor is of tin.

A tripod and observing platform, 8 feet high, were erected to enable observer to see over parapet. The eccentric station was established by making a slight dent in the tin.

Reached by Fulton street elevated train to Franklin avenue station, thence walk west to Atlantic avenue.

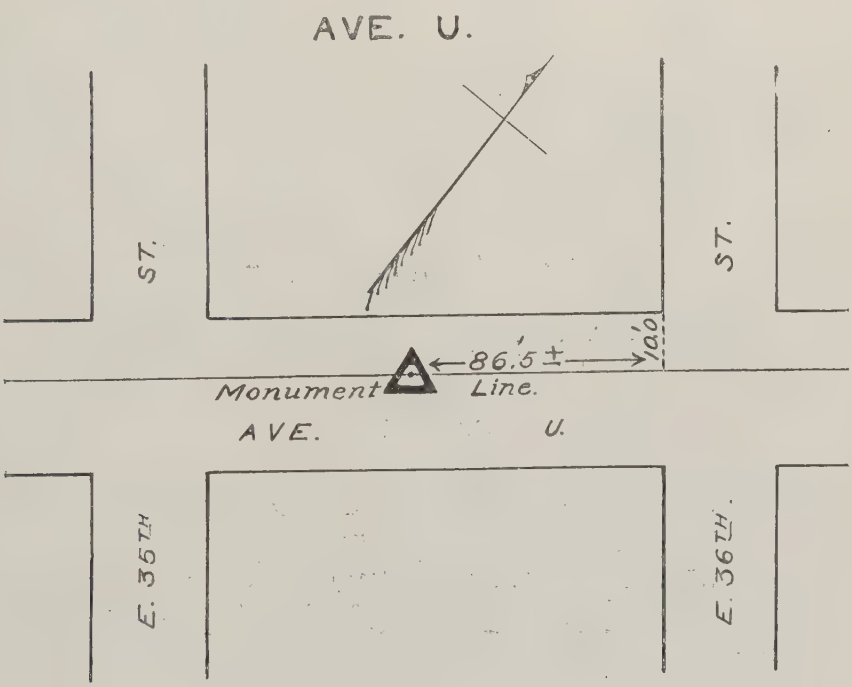


AVENUE U.

This station consists of a 68-foot tripod and scaffold, and is situated on the north side of Avenue U, between Thirty-fifth and Thirty-sixth streets, Flatlands, Borough of Brooklyn, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt.

Reached by taking Flatbush avenue car from Brooklyn Bridge to Avenue N, and walking south one mile to Avenue U, thence ¼ mile west to station.

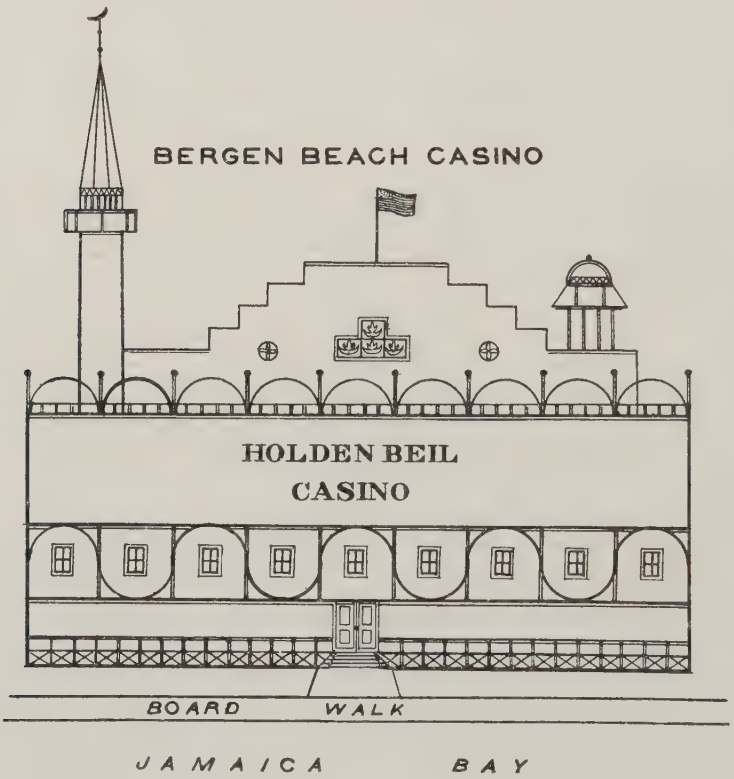


BERGEN BEACH CASINO.

Station Bergen Beach Casino is the pole on the tower of Bergen Beach Casino, Bergen Beach, Borough of Brooklyn, New York City, N. Y.

The building is rectangular in plan, built of wood, and is used as a theatre. It is painted cream color with white trim and has a red roof. The roof of the tower is of tin and is of a dark color. The tower is square in plan with a pyramidal roof. At the base of the roof is an octagonal platform. A small crescent is at the top of the pole.

Reached by Flatbush or Nostrand avenue car to Bergen Beach.



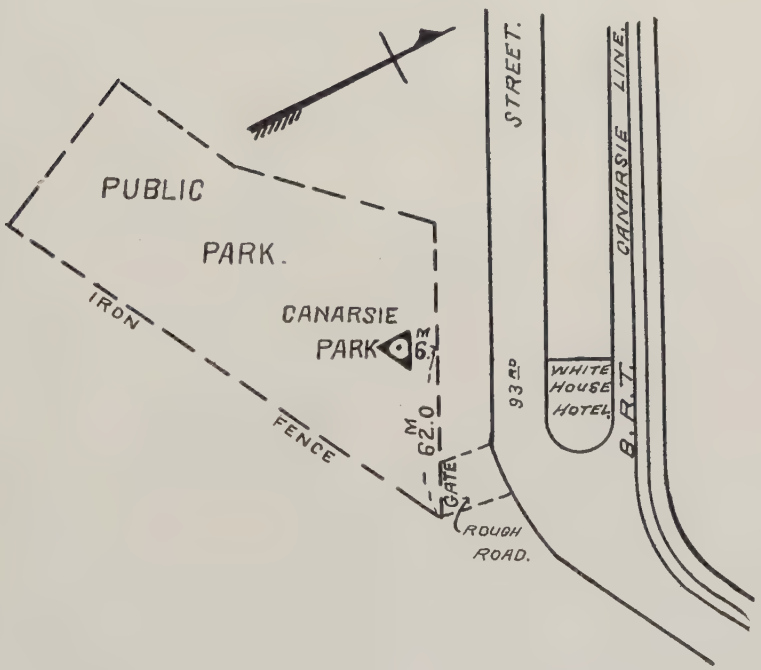
CANARSIE PARK.

Station Canarsie is a 73-foot tripod and scaffold erected in Canarsie Park, situated in Canarsie, Borough of Brooklyn, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt.

Reached by taking Canarsie car at the Williamsburgh Bridge, or from the Brooklyn City Hall by taking the Douglas street car, and changing at Rockaway avenue to Canarsie car, getting off at Canarsie White House Hotel which is but a few hundred feet from the station.

CANARSIE PARK.



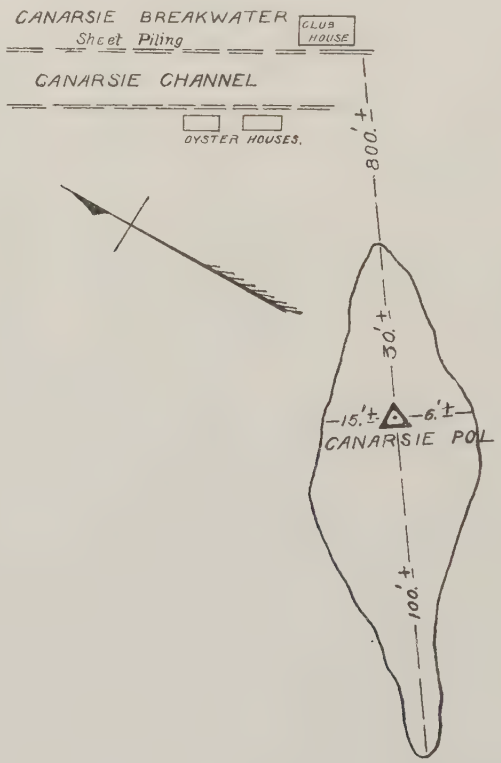
CANARSIE POL.

This station is situated upon an island known as Canarsie Pol, distant about one mile south southeast from Canarsie shore and 800 feet in a southwesterly direction from the southerly end of Canarsie Breakwater.

The island consists of clam shells and is about 130 feet in length, the width varying from 10 to 25 feet.

The monument is located 30 feet ± southwest from the northeasterly end of said island. The monument is of concrete 3′ x 3′ x 3′ upon a driven pile staging. It has iron monument cover, as used by Topographical Bureau, Borough of Brooklyn, and a regular U. S. C. & G. S. brass marking bolt. Top of monument is about one foot above high water mark.

This station may be reached by trolley directly to Canarsie from the Williamsburgh Bridge, or by trolley from Brooklyn Bridge to Rockaway avenue and to Canarsie via Rockaway avenue trolley. From Canarsie take boat to Canarsie Pol.

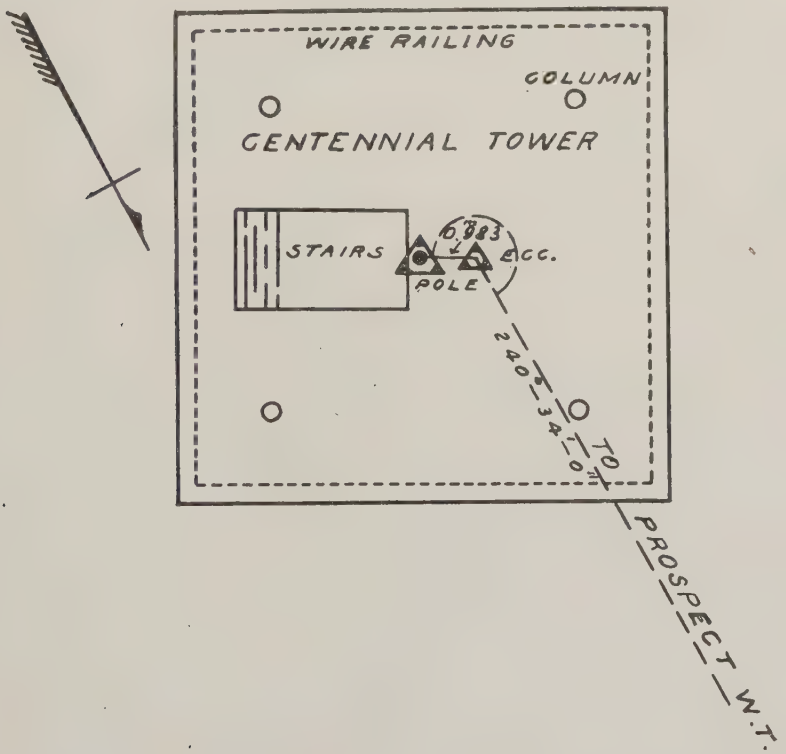


CENTENNIAL TOWER.

This station is the skeleton steel tower known as Centennial Tower and is on Surf avenue, Coney Island.

It is reached by the Coney Island "L" trains from Brooklyn. It is wholly of steel, with an observing platform with a wooden floor. This platform has a flat pyramidal roof over it. The observing platform is reached by two elevators running through the center of the tower to a platform just below the observing platform, which is reached by a couple of flights of stairs. The station is a wooden flagpole which is set into a hollow built up steel tube running from top of tower to platform.

All observations at this station were obtained with difficulty, as the tower was closed each day until 1 P. M., when it was opened to the public who kept moving around the theodolite and platform. The elevators were also kept running during the whole time observations were being made.

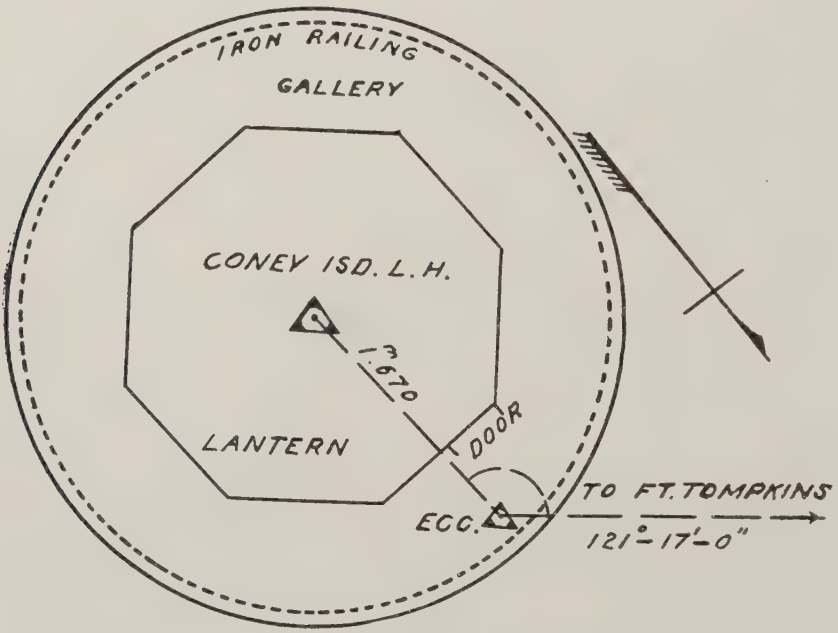


CONEY ISLAND LIGHTHOUSE.

Coney Island Lighthouse is situated on Norton's Point, the western extremity of Coney Island, New York Harbor.

It is reached by Coney Island car from Brooklyn Bridge direct to Coney Island, and then taking hack to Norton's Point, via Sea Gate.

The eccentric station is on the upper gallery on the northwest side of the lantern.

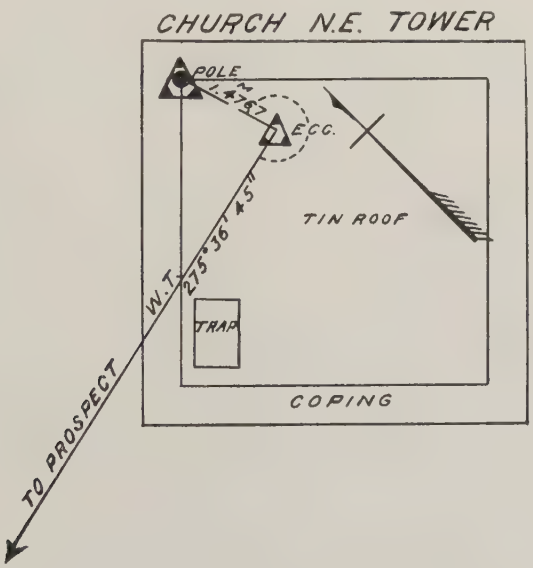


CHURCH, NORTHEAST TOWER.

This station is the flagpole on the northeast tower of the Church of Our Lady of Lourdes, Broadway and Aberdeen street, East New York, Borough of Brooklyn, New York City, N. Y.

The building is of buff-colored brick. The tower is square in plan with a 3-foot tin-covered shelving coping. The floor is also of tin, slightly sloping toward a drain at the southeast corner.

Reached by Cypress Hills elevated train to Chauncey street station, thence walk up Broadway to Aberdeen street.

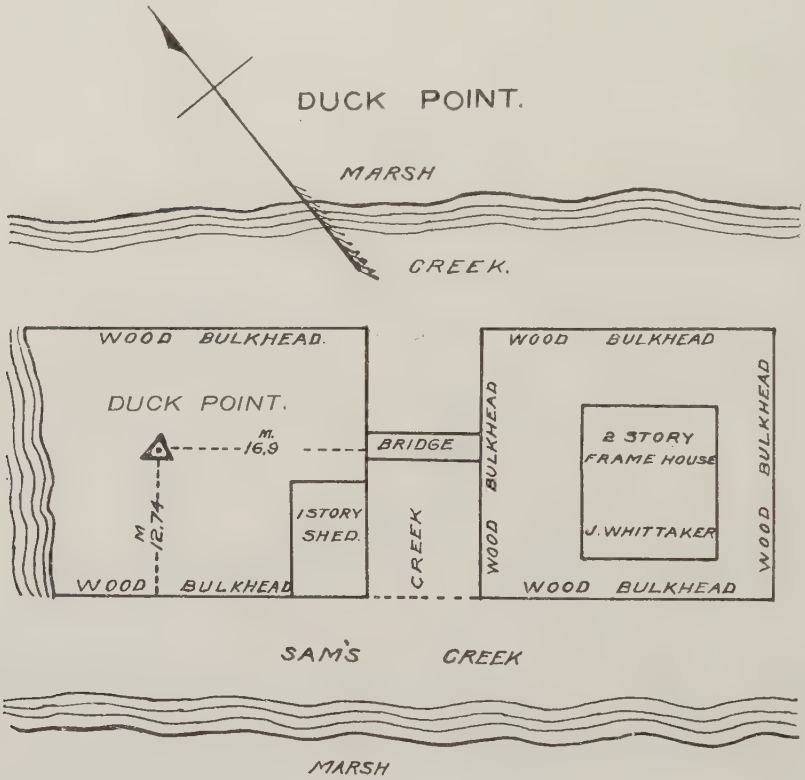


DUCK POINT.

This station is a 16-foot tripod and scaffold, situated on what is known as the "Pumpkin Patch," on the ground of John Whittaker, among the Duck Point marshes.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt.

Reached by launch from Canarsie.

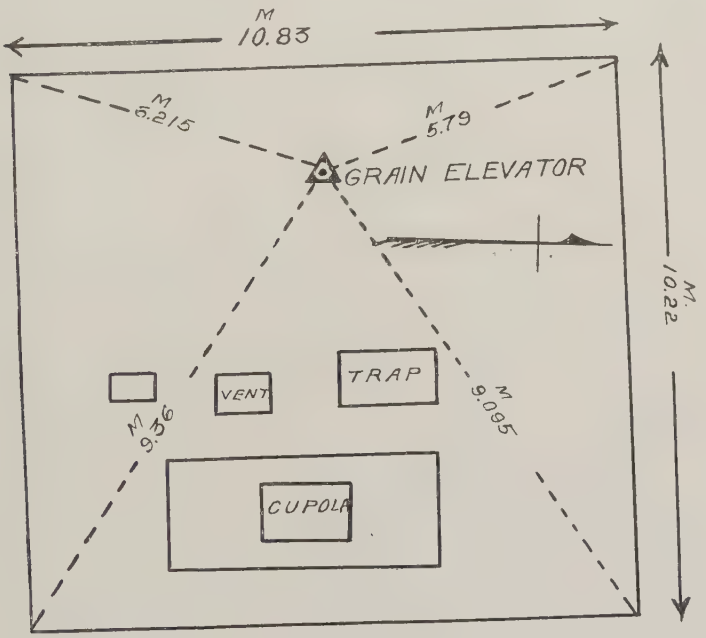


ELEVATOR.

This station is a brass tack set in the roof of the grain elevator which forms a part of the Beard Erie Basin stores, corner of Beard and Van Brunt streets, Erie Basin, Borough of Brooklyn, New York City, N. Y.

The building is of wood, square in plan, with a flat tar and gravel roof. A black and white pole was erected over the station for observing purposes. The station is referenced to the four corners of the roof.

Reached by Crosstown car to foot of Richards street, thence west one block to Beard stores.

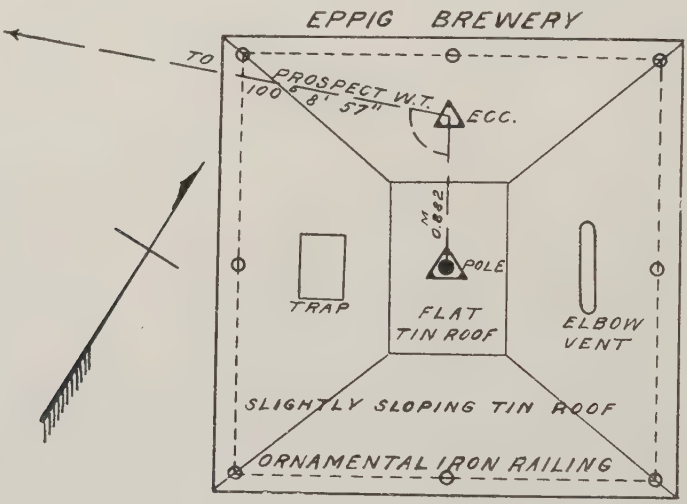


EPPIG BREWERY.

This station is the flagpole on Eppig Brewery tower, located on George street, between Central and Evergreen avenues, Borough of Brooklyn, New York City, N. Y.

The tower is of wood, square in plan, in the form of a truncated pyramid, painted dark with white trim, and has the letters L. E. worked in white on the sides of the tower. The top is flat, of tin, slightly sloping. An ornamental iron railing surrounds the top. The pole is in the center.

Reached by Ridgewood elevated train to Evergreen avenue station, thence walk through Evergreen avenue to George street.



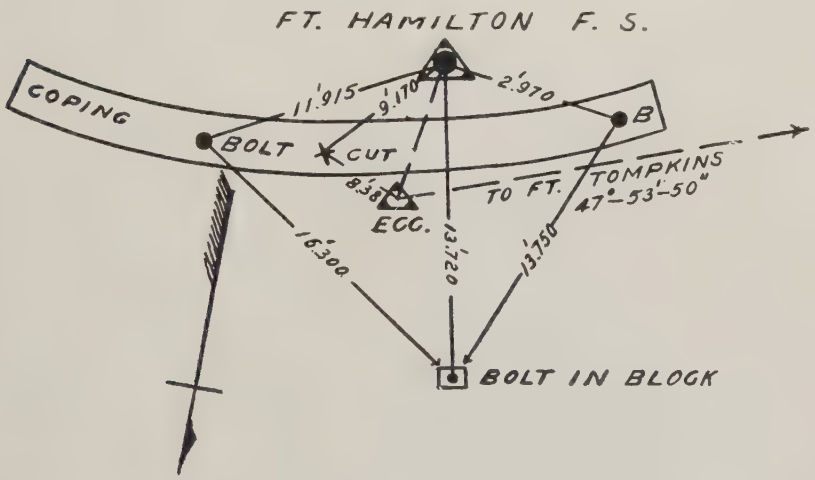
FORT HAMILTON FLAGSTAFF.

This station is the large flagstaff on Old Fort Hamilton, Borough of Brooklyn, New York City, N. Y.

The flagstaff is situated 50 meters ± east of Fort Hamilton avenue and 25 meters ± north of Shore Road.

The station was marked as follows: Two brass bolts were set in the brown stone coping and one brass bolt set in a granite block placed opposite the coping. The top of each bolt is marked by two heavy cuts intersecting at right angles. The bolts were set by order of the Adjutant, Fort Hamilton Reservation, New York.

Reached by electric car from Brooklyn Bridge to Bay Ridge, thence transferring to Fort Hamilton trolley.

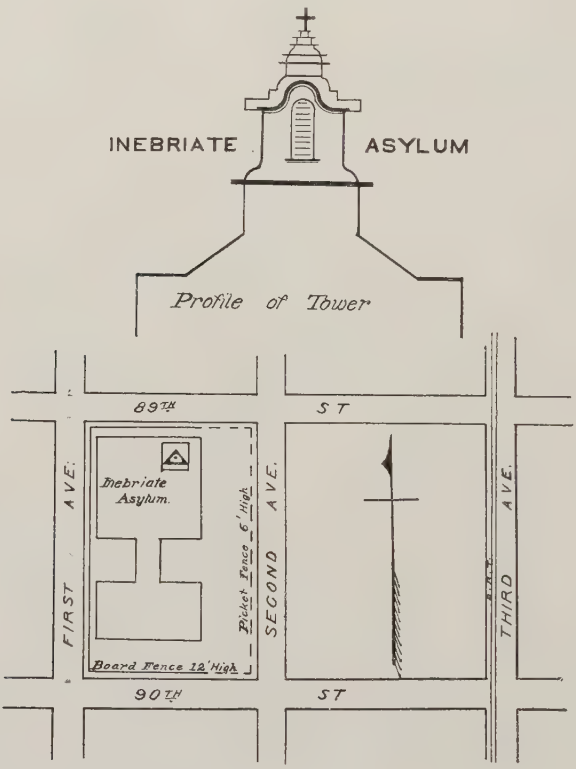


INEBRIATE ASYLUM.

Station Inebriate Asylum is the gilt cross on the tower of the Roman Catholic Convent of the Visitation, Second avenue and Eighty-ninth street, Bay Ridge, Borough of Brooklyn, New York City, N. Y.

The building was formerly an institution for inebriates, but was later converted to religious purposes. It is of white brick with brown roof and trim.

Reached by Fifth avenue and Bay Ridge elevated train to terminus, transfer to Third avenue trolley to Eighty-ninth street.

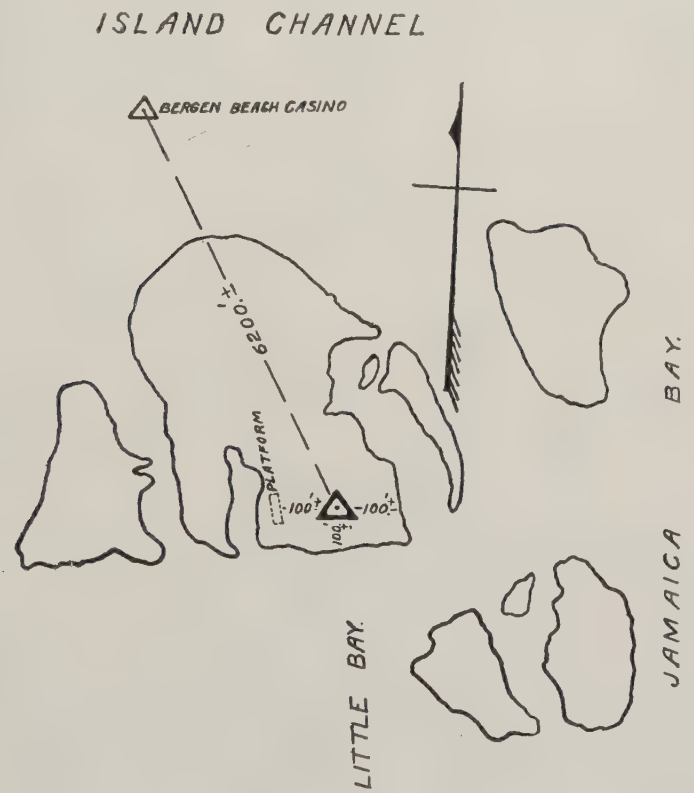


ISLAND CHANNEL.

This station is situated upon an island known as Channel Island, distant 6,200 feet ± in a southeasterly direction from Bergen Beach Casino, 100 feet ± westerly and 100 feet ± northerly from the tide water and easterly 100 feet from a raised platform.

The monument is of concrete 3′ x 3′ x 3′ upon a driven pile staging, and has iron monument cover as used by the Topographical Bureau, Borough of Brooklyn, and a regular U. S. C. & G. S. brass marking bolt. Top of monument is about 3 feet above mean high water mark.

This station may be reached by trolley directly to Canarsie from the Williamsburgh Bridge, or by trolley from Brooklyn Bridge to Rockaway avenue, and to Canarsie via Rockaway avenue trolley. From Canarsie take boat to Island Channel.



KINGS COUNTY ASYLUM.

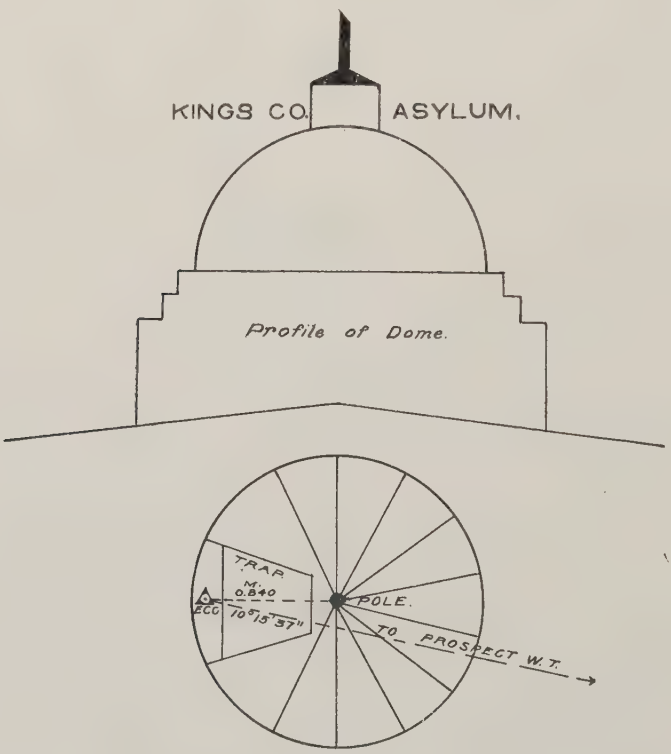
This station is the flagpole on the dome of the Long Island State Hospital for the Insane, and is situated on the north side of Clarkson street, between Albany and Troy avenues, Borough of Brooklyn, New York City, N. Y.

This dome is built of wood, circular in plan, with glass roof, 6 feet in diameter. The roof of this dome was so small and being of glass that no tripod could be put upon it, so instrument had to be mounted on screw-plates fixed on edge of roof in trap opening where eccentric station was established.

Observations on all angles to the east from Thirteenth Regiment Armory to Schoolhouse, Avenue K, were taken by the observer standing in the trap. All angles on the west from Schoolhouse, Avenue K, to Thirteenth Regiment Armory, the observer had to stand on ladder suspended on the outside of dome. This proceeding was necessary owing to only one eccentric station being used.

The eccentric station is 0.8450 meter east of the flagpole and is marked by brass tack driven in the plank.

Reached by Fulton street trolley, transferring to Nostrand avenue car going south to Clarkson street, thence walking east to Albany avenue.

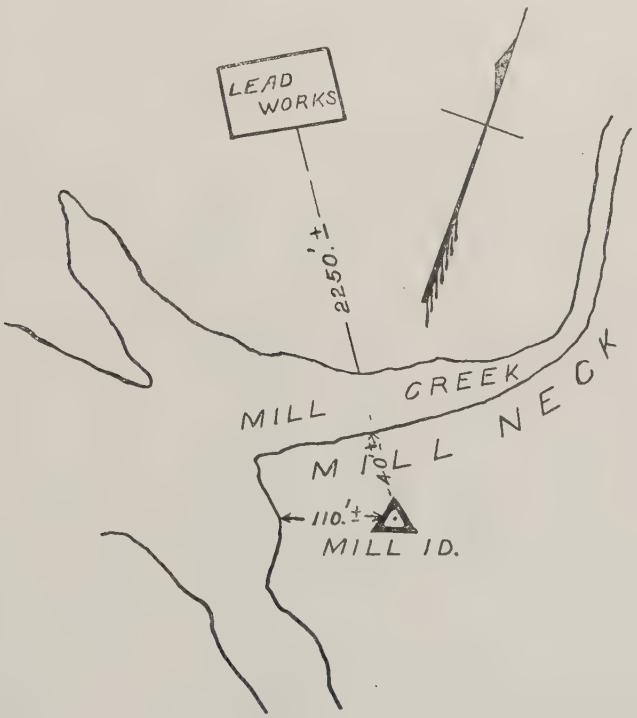


MILL ISLAND.

This station is situated at a point on the main shore known as Mill Neck, distant, in a south southeast direction 7,650 feet ± from the intersection of Ralph avenue and Avenue K, in a southwest direction 4,650 feet ± from Bergen Beach Casino, and in a south southeast direction 2,250 feet ± from the Lead Works.

The monument is of concrete 3′ x 3′ x 3′ upon a driven pile staging and has iron monument cover as used by the Topographical Bureau, Borough of Brooklyn, and a regular U. S. C. & G. S. brass marking bolt. Top of monument is about one and one-half feet above mean high water mark.

This station may be reached by Flatbush avenue trolley from Brooklyn Bridge to Avenue N, thence walking to station, or by boat from Canarsie.



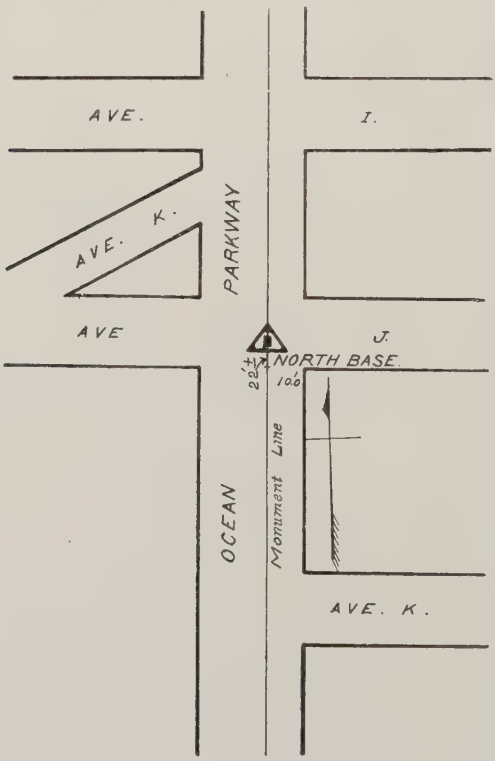
OCEAN PARKWAY NORTH BASE.

Station North Base is situated at the southeast corner of Avenue J and Ocean Parkway, Borough of Brooklyn, New York City, N. Y.

The station consists of a 52-foot tripod and scaffold, with a 25-foot black and white pole, and is on the monument line of Ocean Parkway.

The station was marked in the following manner: A granite block 8″ x 8″ on top, 8″ x 24″ on bottom and 30 inches high, was set in concrete, the whole making a solid mass 4′ x 4′ x 4′. The center was marked with a U. S. C. & G. S. marking bolt set in the granite block and exactly under the center of the station. An iron-hinged cover was placed over the stone.

Reached by taking a Coney Island avenue trolley to Avenue J, and walking west to Ocean Parkway.



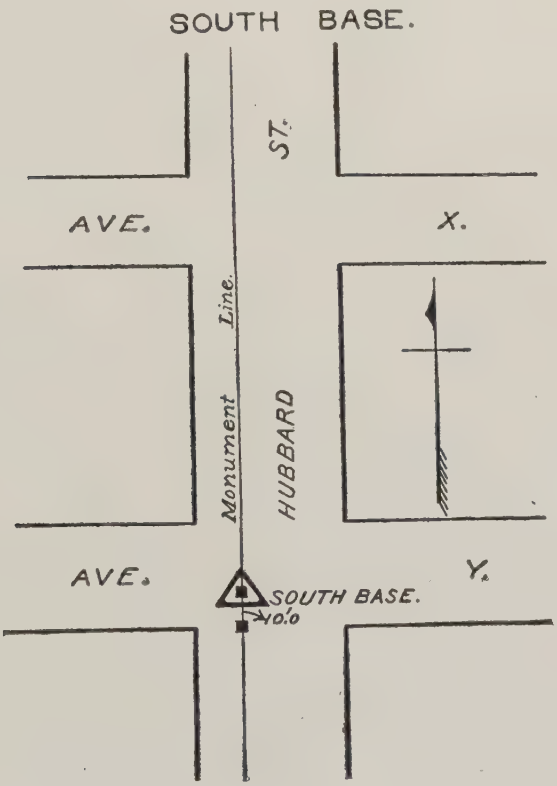
OCEAN PARKWAY SOUTH BASE.

Station South Base is situated at the southwest corner of Avenue Y and Hubbard street, Borough of Brooklyn, New York City, N. Y.

The station consists of a 52-foot tripod and scaffold, with a 25-foot black and white pole, and is on the monument line of Hubbard street.

The station was marked in the following manner: A granite block 8″ x 8″ on top, 8″ x 24″ on bottom, and 30 inches high, was set in concrete, the whole making a solid mass, 4′ x 4′ x 4′. The center was marked with a U. S. C. & G. S. marking bolt set in the granite block and exactly under the center of the station. An iron-hinged cover was placed over the stone.

Reached by Coney Island avenue trolley to Avenue Y, thence west to Hubbard street which is a continuation of Ocean Parkway.

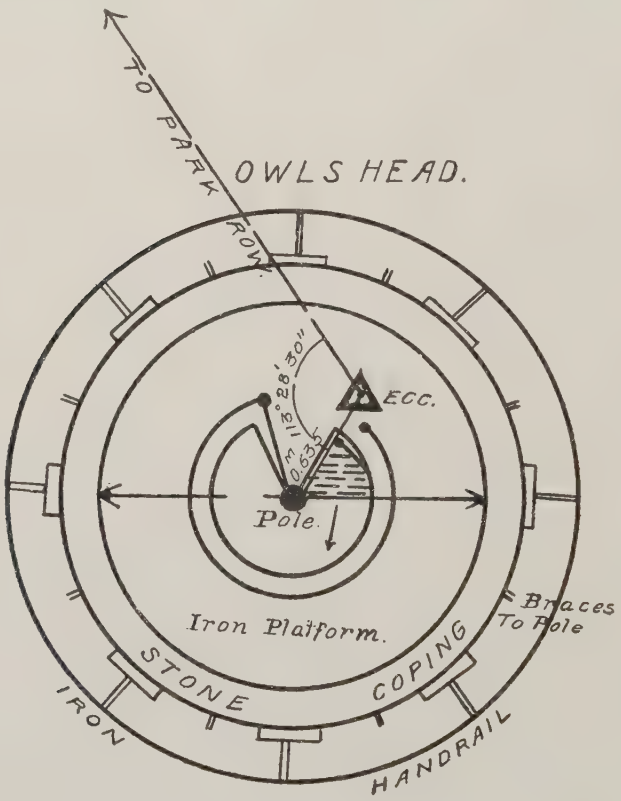


OWL HEAD.

This station is the flagpole on the stone tower on the estate of Mr. E. W. Bliss, foot of Sixty-seventh street, Bay Ridge, Borough of Brooklyn, New York City, N. Y.

The tower is circular in plan with an iron platform. The eccentric station was established by crosscut chiseled in this platform.

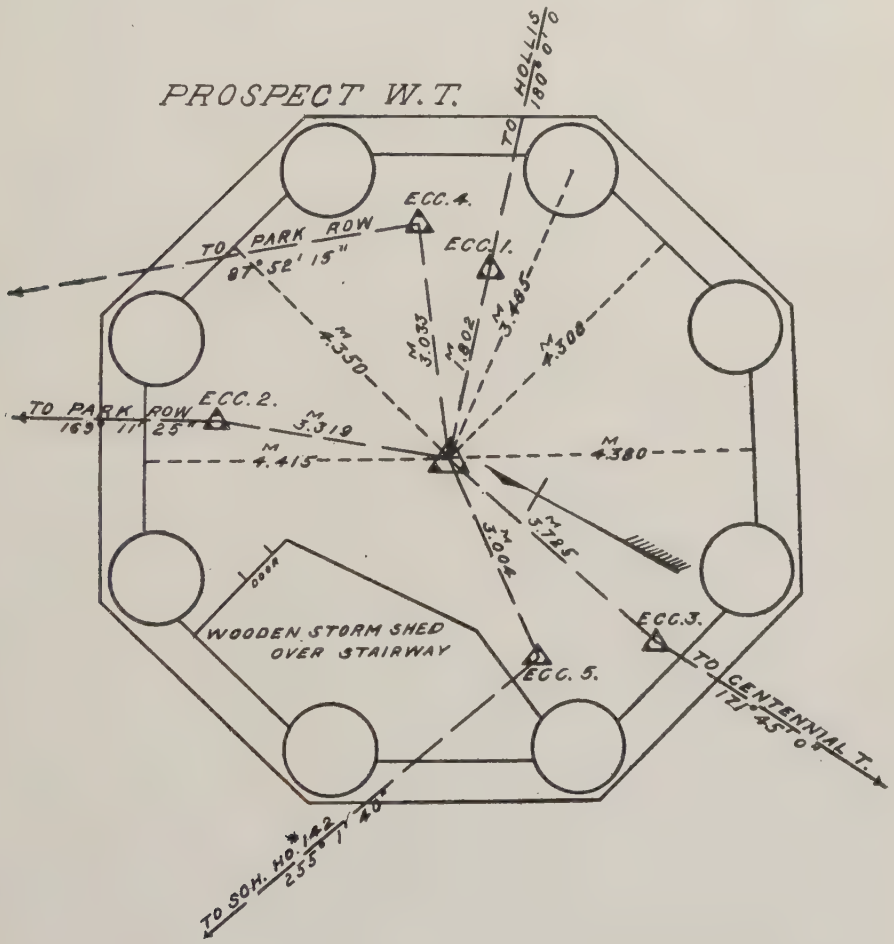
Reached by Fifth avenue and Bay Ridge elevated train or Third avenue trolley to Third avenue and Sixty-fifth street, thence west to Bliss estate, through said property, to tower.



PROSPECT WATER TOWER.

This station is a high masonry tower with a conical apex, and is situated at the southeast corner of Flatbush avenue and Eastern Parkway, Borough of Brooklyn, Kings County, New York City, N. Y. It was occupied at various times during 1903, 1904, 1905 and 1907 by Mr. Frederick W. Koop, Assistant Engineer, who determined the center by suspending a heavy plumb bob from the apex of the tower; the center was also checked by plumbing the apex down with a transit. The center was marked by a copper bolt ½ inch in diameter, countersunk in the concrete floor and fastened with solder.

Station is reached by Flatbush avenue trolley from Brooklyn Bridge, getting off at Eastern Parkway.

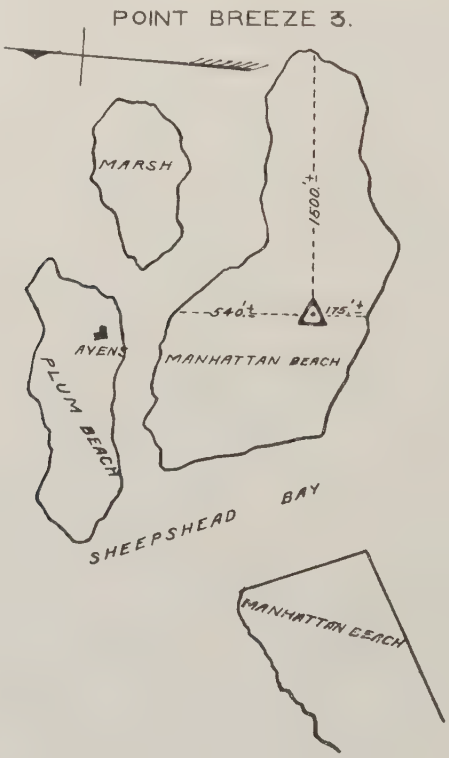


POINT BREEZE 3.

This station is situated on Manhattan Beach, 1,500 feet ± west of extreme east end of beach, 175 feet ± from tide water at a point directly opposite bell buoy, and 540 feet ± at a point directly opposite George Ayen's Hotel, on Plum Beach.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′x 4′. The exact point is a small hole drilled in top of bolt.

Reached by Brighton Beach elevated train to Sheepshead Bay, thence by boat to Point Breeze.



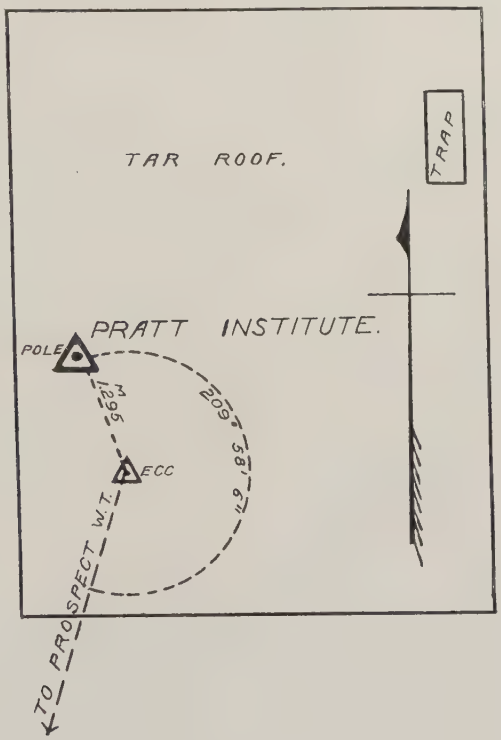
PRATT INSTITUTE.

This station is the flagpole on Pratt Institute, situated on the east side of Ryerson street, between Willoughby street and De Kalb avenue, Borough of Brooklyn, New York City, N. Y.

This building is of brick, six stories high, with square open tower.

The eccentric station is 1.295 meters south of flagpole and is marked by brass tack driven in roof.

Reached by Lexington avenue train to De Kalb avenue, thence walking west to Ryerson street, thence north one block to Pratt Institute.

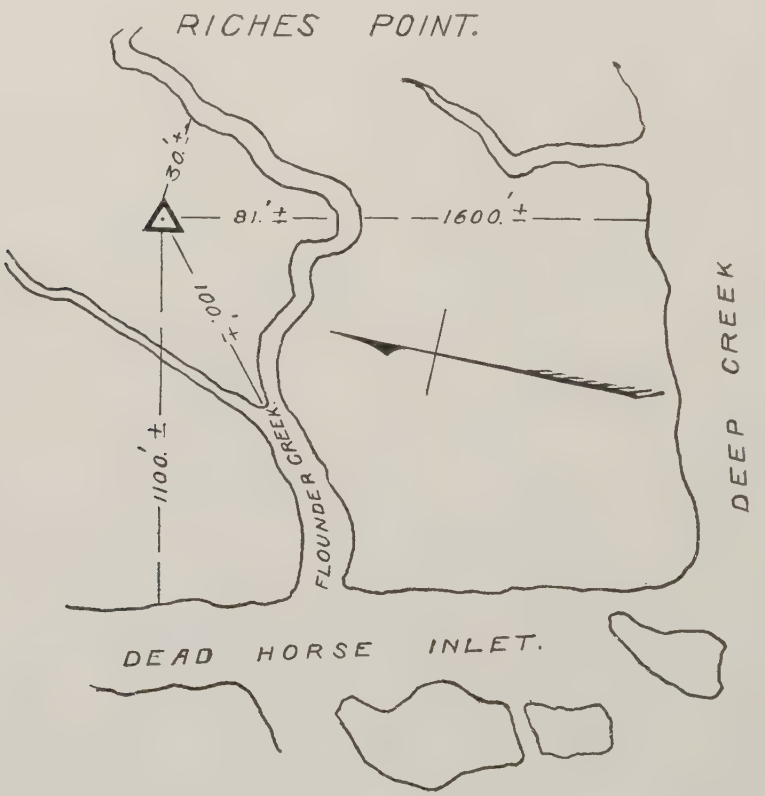


RICHES POINT.

This station is situated upon an island known as Riches Point Meadow, distant in an easterly direction, 1,100 feet ± from Dead Horse Inlet; in a northerly direction, 1,600 feet ± from Deep Creek, and in a northeasterly direction, 100 feet from the junction of Flounder and Little Flounder creeks.

The monument is of concrete 3′ x 3′ x 3′ upon a driven pile staging, and has iron monument cover as used by the Topographical Bureau, Borough of Brooklyn, and a regular U. S. C. & G. S. brass marking bolt. Top of monument is about two feet above mean high water mark.

This station may be reached by trolley direct to Canarsie from the Williamsburgh Bridge, or by trolley from Brooklyn Bridge to Rockaway avenue, and to Canarsie via Rockaway avenue trolley. From Canarsie take boat to Riches Point.

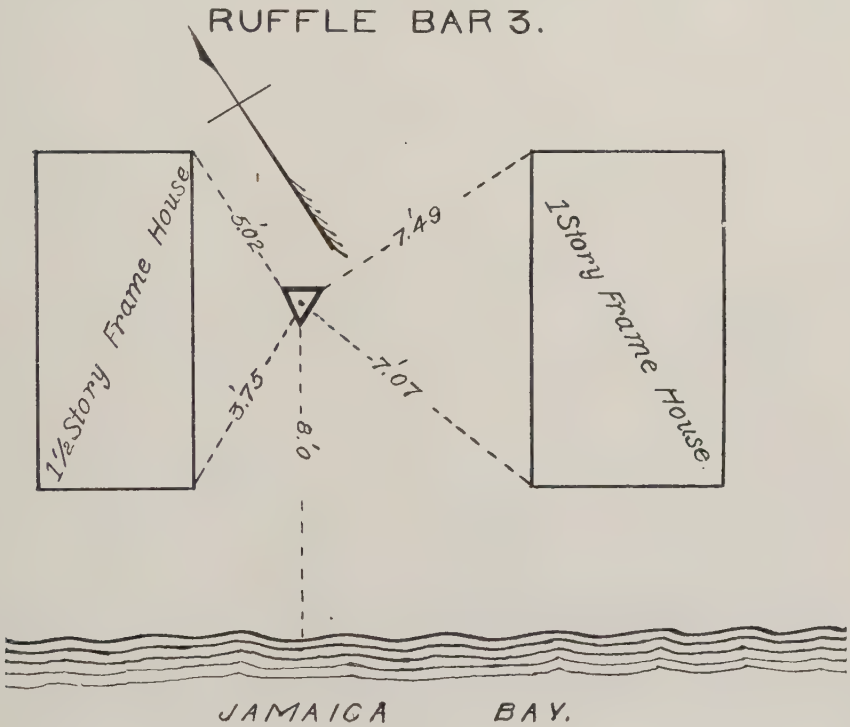


RUFFLE BAR 3.

This station is near the old U. S. C. & G. S. station of 1885, on the south side of Ruffle Bar and consists of a 30-foot tripod and scaffold erected under the direction of the Highway Department of the Borough of Brooklyn.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt.

Reached by launch from Rockaway Beach or from Canarsie.

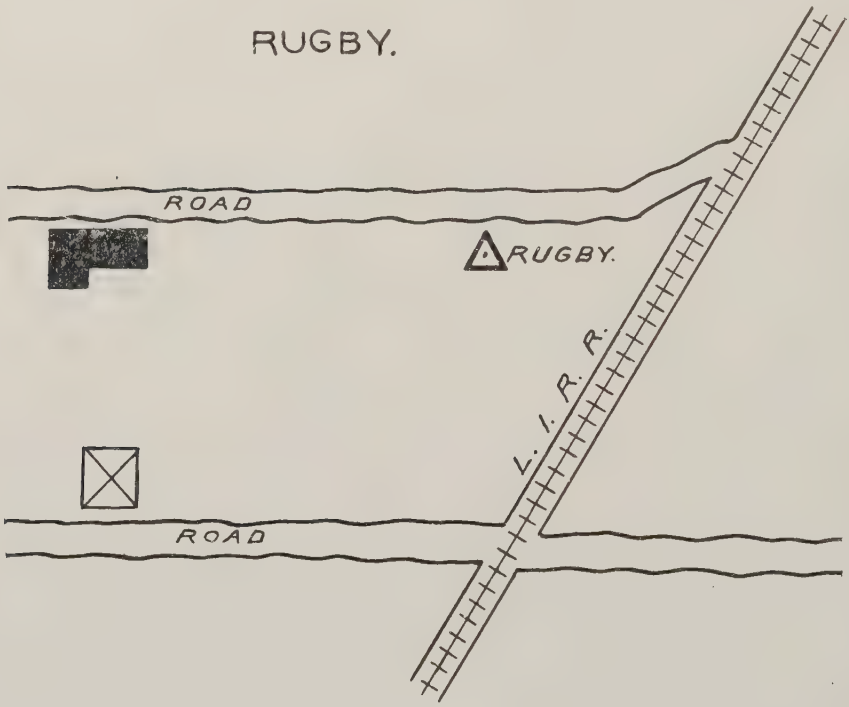


RUGBY.

Station Rugby is a 52-foot tripod and scaffold erected on the west side of Eighty-fifth street, between Avenues C and D, Borough of Brooklyn, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. The exact point is a small hole drilled in top of bolt. This monument is 4 feet below the surface of the ground and is covered with a board, on top of which the earth was thrown. The station is marked on the surface with a wooden stake in which is placed a brass tack.

Reached by Brooklyn elevated train to Rockaway avenue, thence by trolley to Church avenue, thence west on Church avenue to Eighty-fifth street and walking east to station.



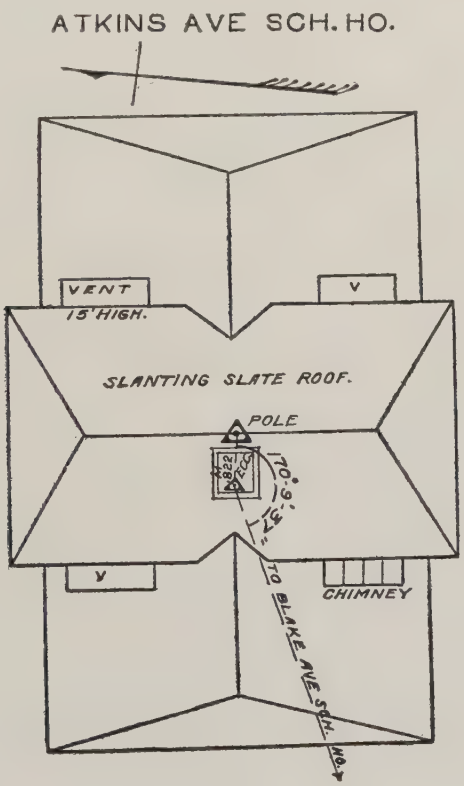
SCHOOLHOUSE, ATKINS AVENUE.

This station is the flagpole on Schoolhouse No. 64, situated on the west side of Atkins avenue, between Belmont and Berriman streets, Borough of Brooklyn, New York City, N. Y.

This building is four stories high, red brick, mansard slate roof, and has four ventilators 15 feet high.

Observations on Canarsie Park, Blake Avenue School, Ridgewood Gate House, Spruce Street School and Spring Creek were made from eccentric station No. 1, which was established 1.1525 meters southwest of flagpole, on scuttle door in roof. Eccentric station No. 1 is marked by crosscut + in copper.

Church northeast tower could not be seen from eccentric station No. 1 on account of high vent in line, and eccentric station No. 2 was established 7.0755 meters southwest of flagpole on angle of roof. Eccentric station No. 2 is marked by crosscut + in copper.



SCHOOLHOUSE, BARREN ISLAND.

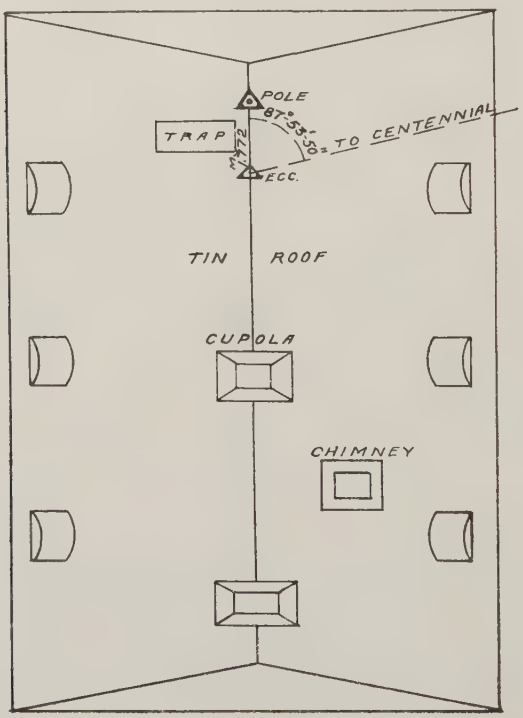
This station is the flagpole on Public School No. 120, Barren Island, Borough of Brooklyn, New York City, N. Y.

The building is a two and one-half-story frame structure with a sloping tin roof.

Owing to there being no level surface on the roof, a tripod and scaffold were erected for observing purposes. The eccentric station was marked by a brass tack driven in the roof.

Reached by Fulton elevated train to Rockaway avenue, transferring to Hamburg avenue trolley to Canarsie; thence by boat to Barren Island.

BARREN ID. SCH. HO.



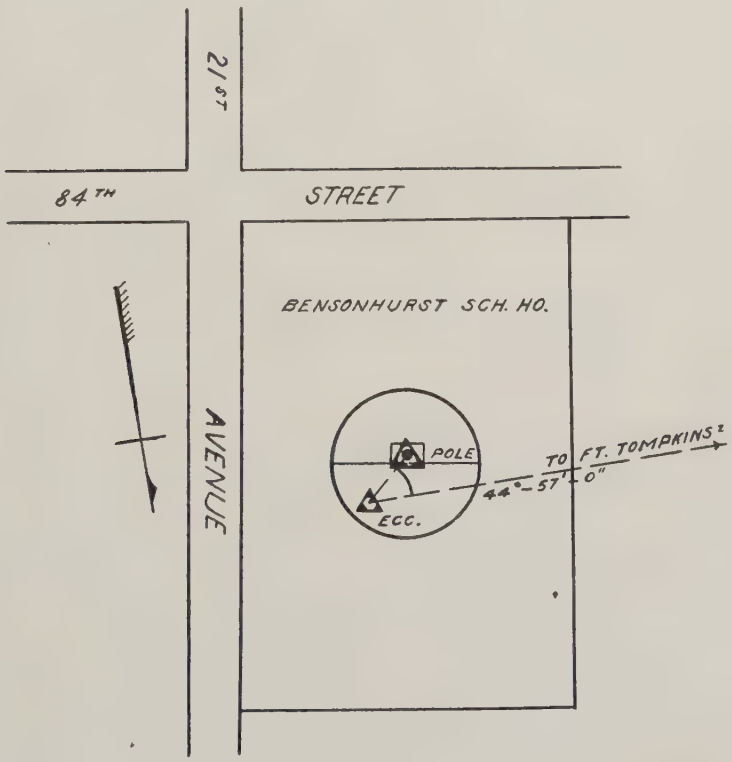
SCHOOLHOUSE, BENSONHURST.

Station Schoolhouse, Bensonhurst, is situated on the northwest corner of Eighty-fourth street and Twenty-first avenue, Bensonhurst, Borough of Brooklyn, New York City, N. Y.

It is a four-story stone and brick structure with a mansard roof. In the center of the roof is a cylindrical balustrade with flagstaff almost in the center. The flagstaff is the station.

The eccentric station is on the top of the north half of the balustrade.

The schoolhouse is reached by Bath Beach and Ulmer Park car from Brooklyn Bridge, getting off at Bay Twenty-fifth street and walking northeast to schoolhouse.



SCHOOLHOUSE, BLAKE AVENUE.

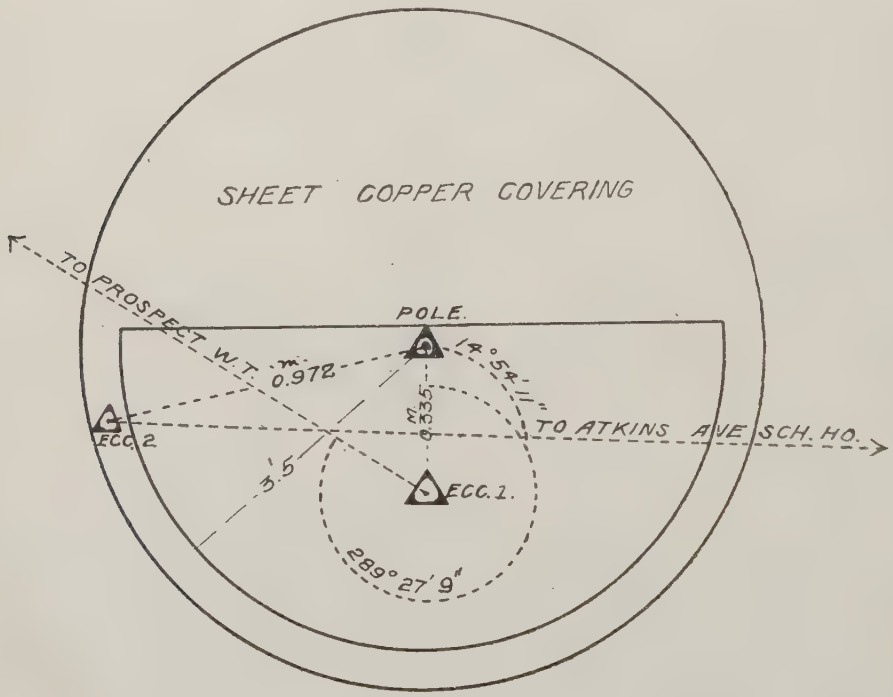
This station is the flagpole on Schoolhouse No. 125, situated on the east side of Blake avenue, between Rockaway and Thatford avenues, Borough of Brooklyn, New York City, N. Y.

This building is brick with gray stone trimming and has a mansard slate roof with circular turret, 7 feet in diameter and 6 feet high, in center of which is the flagpole. This turret is circular in plan, one-half of which is solid with sheet copper covering.

Observations were made from eccentric station No. 1 in the open part of turret 0.3350 meter from pole. A small platform was built on which tripod legs rested in order to elevate the instrument to see over side of turret.

Observations were made from eccentric station No. 2 on the coping of turret 0.9725 meter southwest of flagpole. The instrument was mounted on a small piece of board set in plaster of paris and was very rigid.

BLAKE AVE. SCH. HO.

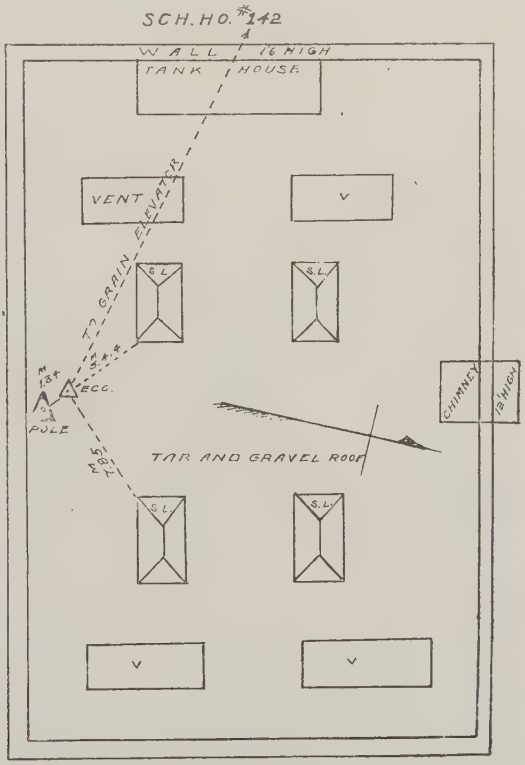


SCHOOLHOUSE NO. 142.

This station is the flagpole on Schoolhouse No. 142, situated on the west side of Henry street, between Rapelyea and Coles streets, Borough of Brooklyn, New York City, N. Y.

The building, four stories high, is of brick with gray stone trimming and flat tar and gravel roof.

Observations were taken from an eccentric station 1.3425 meters west of flagpole. Eccentric station is marked with a brass tack driven in roof.



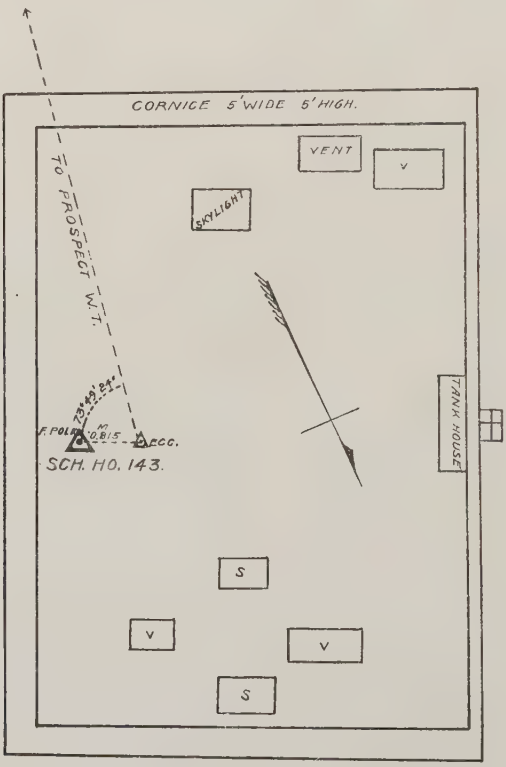
SCHOOLHOUSE NO. 143.

This station is the flagpole on Schoolhouse No. 143, situated on the west side of Havemeyer street, between North Sixth and North Seventh streets, Borough of Brooklyn, New York City, N. Y.

This is a square brick building, four stories high, flat tar and gravel roof with several vents and skylights 8 to 10 feet high.

A tripod and scaffold, 9 feet high, was erected over eccentric station in order to see over these vents and skylights and also over the cornice around building. This eccentric station is 0.8150 meter west of flagpole and is marked with brass tack driven in roof.

Reached by crosstown car to North Sixth street, thence two blocks east to school.



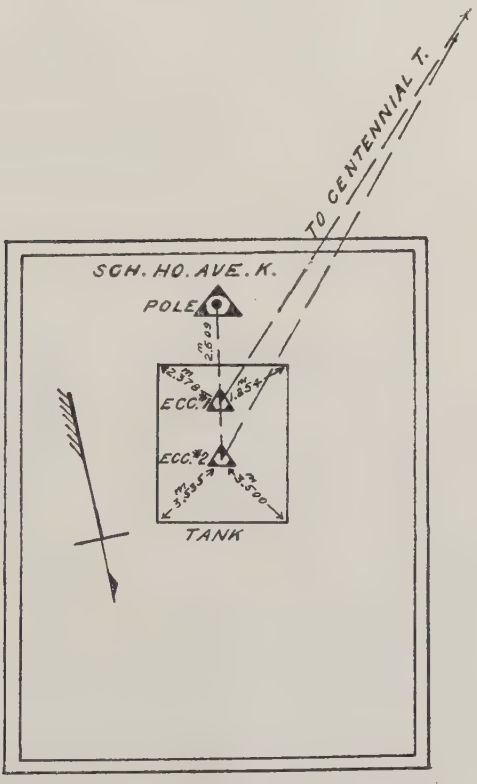
SCHOOLHOUSE, AVENUE K.

This station is the flagpole on Public School No. 119, situated on the north side of Avenue K, between Thirty-eighth and Thirty-ninth streets, Borough of Brooklyn, New York City, N. Y.

The schoolhouse has a flat gravel roof, near the front of which is a large iron tank inclosed in a fireproof brick building with a copper roof.

Eccentric stations 1 and 2 are on top of this tank building, which is a very poor place for both instrument and observer, but is the best we can do at this station.

Reached by Flatbush avenue trolley to Avenue K.



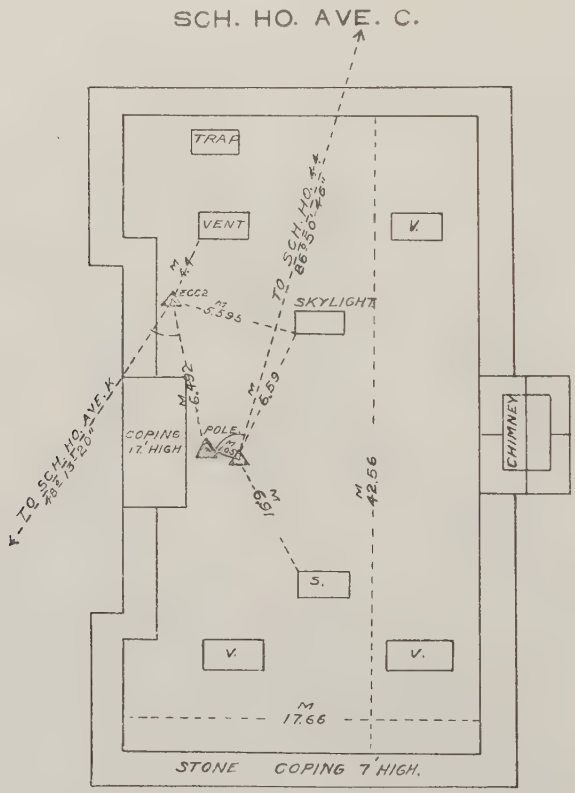
SCHOOLHOUSE, AVENUE C.

This station is the flagpole on Public School No. 139, Avenue C, East Thirteenth and Fourteenth streets, Flatbush, Borough of Brooklyn, New York City, N. Y.

The building is of brick, rectangular in plan, with a flat tar and gravel roof. The roof is surmounted by a 7-foot stone coping. Owing to this fact a wooden tripod 10 feet high, together with an observing platform, had to be erected.

On account of ornaments on the coping, extending to a height of 17 feet, directly south of the pole, two eccentric stations had to be established, points to the east, west and north being taken from Eccentric No. 1 and southerly points from Eccentric No. 2. These eccentric stations were established by brass tacks driven in the roof.

Reached by Brighton Beach elevated train to Avenue C and thence west one block to school.



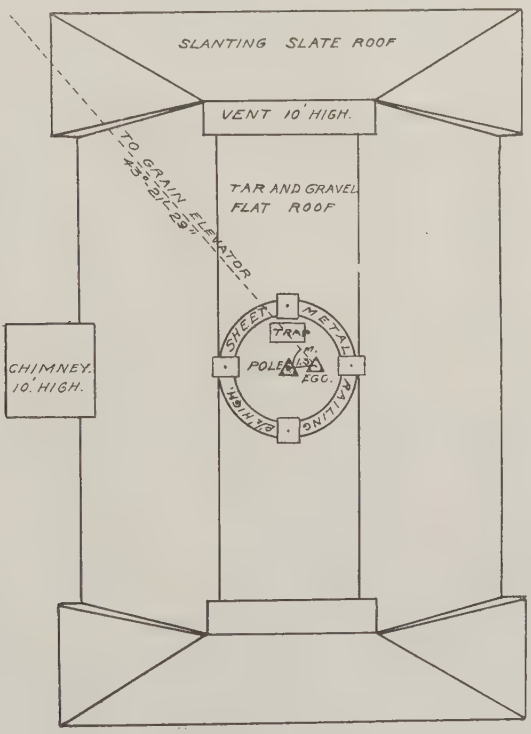
SCHOOLHOUSE, FORTY-FIRST STREET.

This station is the flagpole on Schoolhouse No. 136, situated on the west side of Fourth avenue, between Fortieth and Forty-first streets, Borough of Brooklyn, New York City, N. Y.

This building is of brick with gray stone trimming. The middle portion of roof is flat, tar and gravel, and the remaining portion, which is slated, slopes to the outside walls.

Observations were made on an eccentric station 0.225 meter east of flagpole. The eccentric is marked with brass tack.

SCH. HO. 41ST ST.

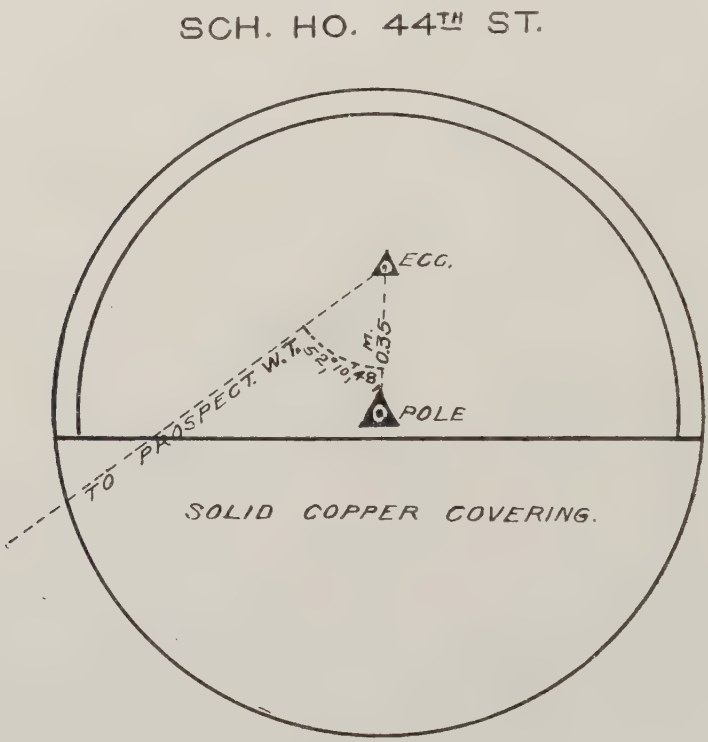


SCHOOLHOUSE, FORTY-FOURTH STREET.

This station is the flagpole on Schoolhouse No. 131, situated on Fort Hamilton Parkway, between Forty-third and Forty-fourth streets, Borough of Brooklyn, New York City, N. Y.

This building is of brick with gray stone trimming, and has a mansard slate roof with circular turret, 7 feet in diameter and 6 feet high, in center of which is the flagpole. This turret is circular in plan and half of which is solid with sheet copper covering.

Observations were made from eccentric station in the open part of turret 0.350 meter from pole. A small platform was built on which tripod legs rested in order to elevate the instrument to see over sides of turret.



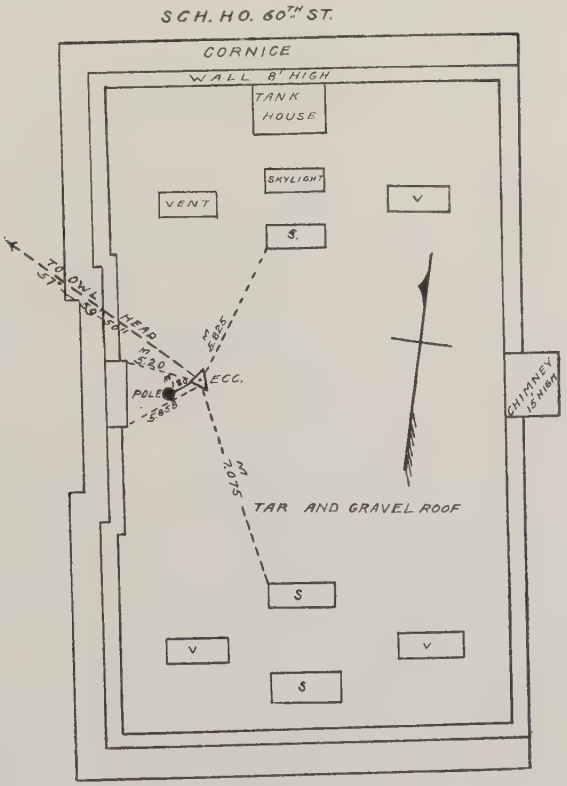
SCHOOLHOUSE, SIXTIETH STREET.

This station is the flagpole on Schoolhouse No. 140, situated on the north side of Sixtieth street, between Third and Fourth avenues, Borough of Brooklyn, New York City, N. Y.

This building is of brick with gray stone trimming, flat tar and gravel roof, with several skylights and vents 6 feet high.

On the east, west and south sides of the building the walls are 8 feet higher than roof and it was necessary to build a tripod in order to elevate the instrument to see Schoolhouse, Seventy-ninth street, Inebriate Asylum and Owl Head.

Observations were made on eccentric station 1.800 meters north of flagpole. The eccentric station is marked by wire nail driven in roof and referenced as in sketch.



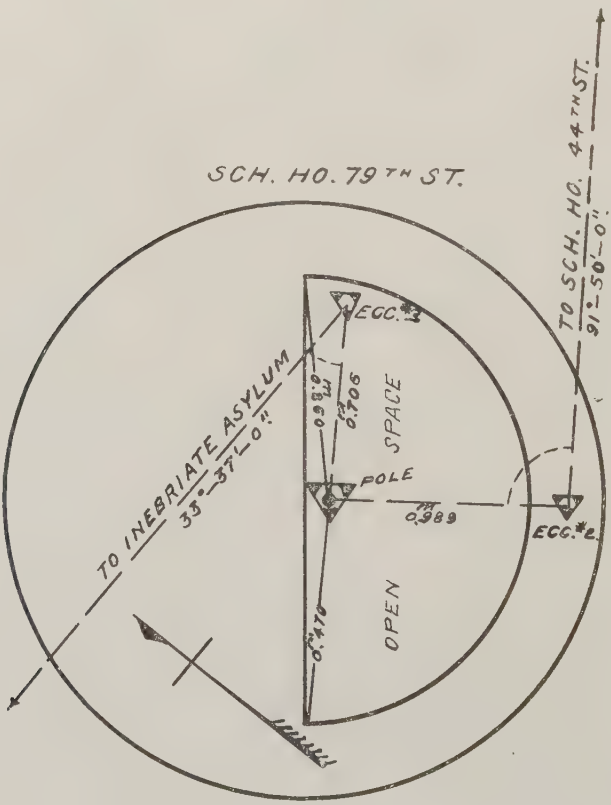
SCHOOLHOUSE, SEVENTY-NINTH STREET.

This station is Public School No. 127 and is situated at the northeast corner of Seventy-ninth street and Fort Hamilton avenue, Borough of Brooklyn, New York City, N. Y.

It is a four-story brick and stone structure with a mansard roof. In the center of the roof a cylindrical balustrade with a flagstaff near the center. The flagstaff is the station.

The eccentric stations are on top of the balustrade as shown in sketch, and though they are the best points available, are very difficult to observe from. It is practically impossible to observe from outside the balustrade and great care must be taken not to touch any part of the balustrade, which is covered with loose copper and which raises the eccentric station when touched. In general the conditions at Eccentric No. 1 are better than those at Eccentric No. 2.

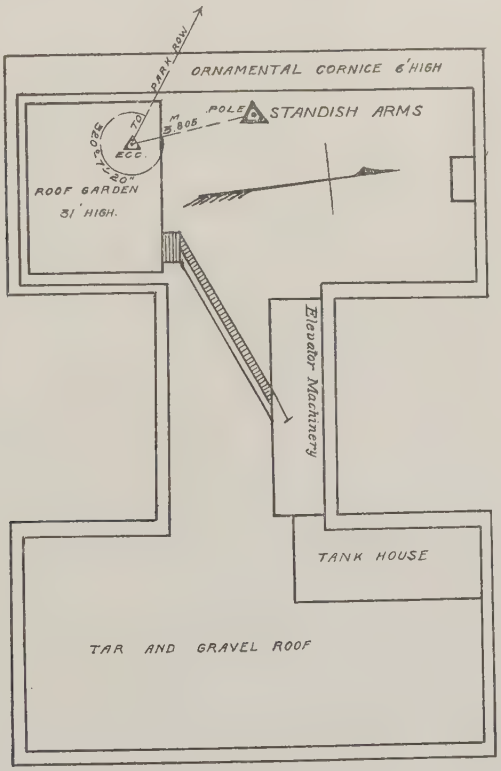
The schoolhouse is reached by Fifth avenue trolley from Brooklyn Bridge.



STANDISH ARMS.

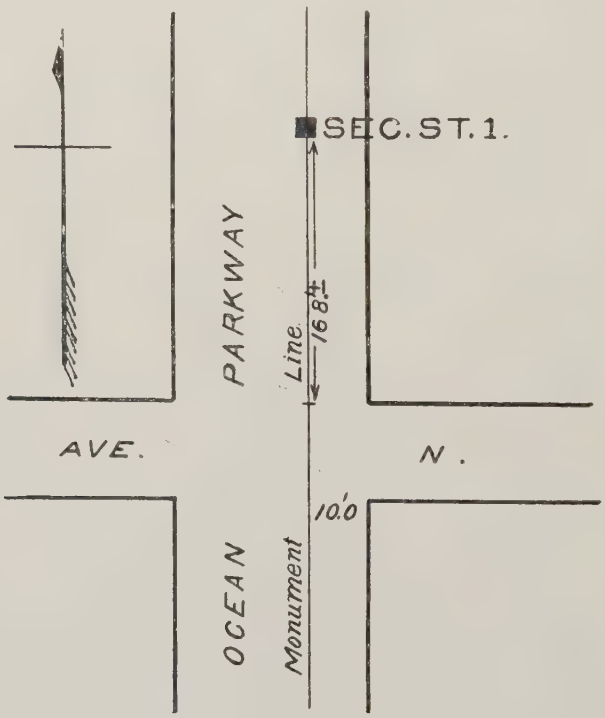
This station is the flagpole on the apartment house known as the Standish Arms, situated at Columbia Heights, Borough of Brooklyn, New York City, N. Y.

The building is of brick, 13 stories high, and has a tar and gravel roof, on the southwest end of which is a wooden platform used as a summer garden and on which eccentric station was established and observations taken. Eccentric station is 3.805 meters from flagpole and is marked by a brass tack.



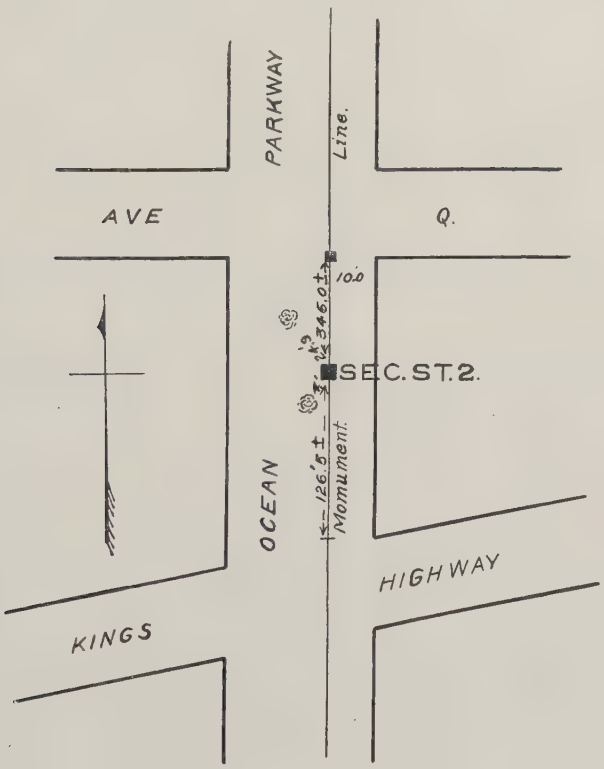
SECTION STONE I, OCEAN PARKWAY BASE LINE.

This stone marks the south end of the first section of the Ocean Parkway Base Line, and is on a 10.0-foot off-set to the easterly line of Ocean Parkway, 168 feet + north of Avenue N. The point consists of a small hole in a copper bolt, set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. It is reached by Smith street car to Avenue N and walking west to Ocean Parkway.



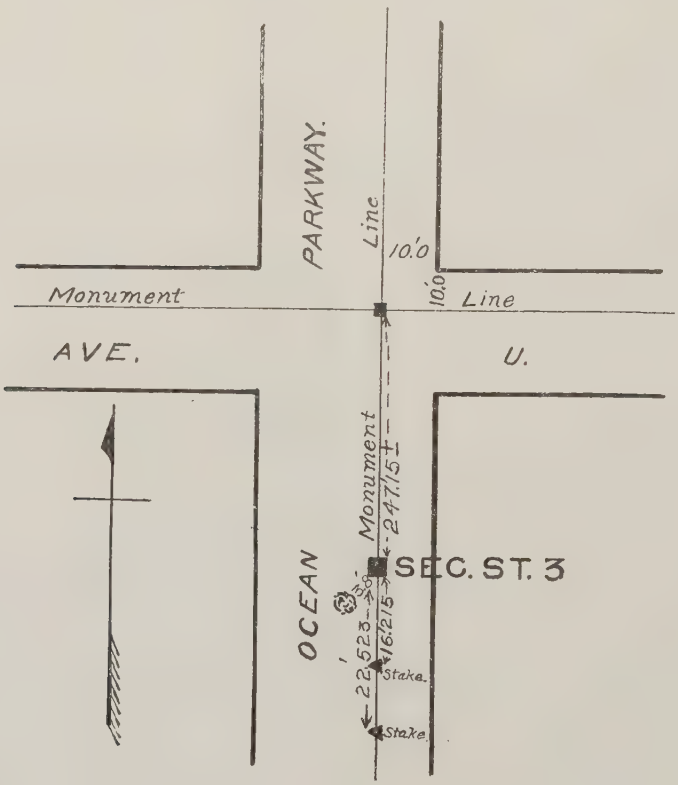
SECTION STONE II, OCEAN PARKWAY BASE LINE.

This stone marks the south end of the second section of the Ocean Parkway Base Line, and is on a 10.0-foot off-set to the easterly line of Ocean Parkway, 126.5 feet north of Kings Highway. The point consists of a small hole in a copper bolt, set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. It is reached by Smith street car to Kings Highway and walking west to Ocean Parkway.



SECTION STONE III, OCEAN PARKWAY BASE LINE.

This stone marks the south end of the third section of the Ocean Parkway Base Line, and is on a 10.0-foot off-set to the easterly line of Ocean Parkway 247.15 feet south of the monument line of Avenue U. The point consists of a small hole in a copper bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. It is reached by Smith street car to Avenue U and walking west to Ocean Parkway.



SMITH AND GRAY TOWER.

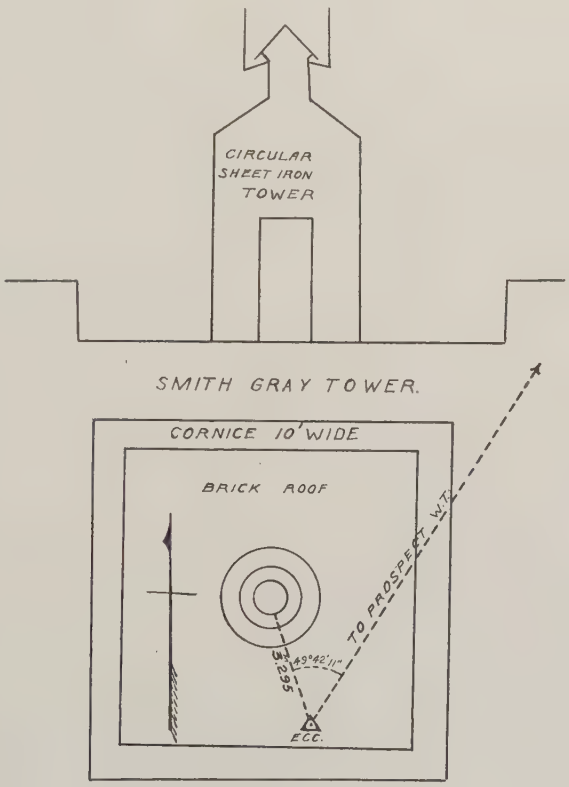
This station is the center of the top of the circular tower on top of the clock tower of the Smith and Gray Building, situated on the corner of Flatbush avenue and Fulton street, Borough of Brooklyn, New York City, N. Y.

The clock tower is square in plan, 25′ x 25′, with flat brick roof in the center of which is a circular sheet iron tower with a door, used as a covering for stairway and also as a ventilator.

This circular tower has a hood, the center of which was used as the station. Around this hood is a circular band higher than the top of hood.

The eccentric station is 3.295 meters west of tower and is marked with crosscut + in brick.

Reached by Fulton street car to Flatbush avenue.



Borough of Queens.

BOROUGH OF QUEENS.

RECTANGULAR CO-ORDINATES.

Prospect Water Tower = Origin of Axes. True Meridian at Prospect Water Tower = Axis of Ordinates.

No.	Station.	X in Meters.	X in Feet.	Y in Meters.	Y in Feet.
1	Aqueduct schoolhouse	— 11752.062	— 38556.556	— 703.089	— 2306.718
2	Arverne Hotel	— 14338.720	— 47042.950	— 9289.097	— 30475.979
3	Bayhead Hotel	— 18951.377	— 62176.309	— 3730.817	— 12238.548
4	Bayside	— 15388.671	— 50487.664	+ 11396.463	+ 37389.895
5	Belle Harbor church	— 10080.607	— 33072.791	— 10687.793	— 35064.867
6	Belmont	— 20419.236	— 66992.109	+ 4590.719	+ 15061.384
7	College Point schoolhouse	— 10232.856	— 33572.295	+ 12580.280	+ 41273.802
8	Covert avenue schoolhouse	— 4725.647	— 15504.060	+ 3651.513	+ 11980.095
9	Consumers brewery	— 5086.718	— 16688.674	+ 7485.215	+ 24557.743
10	Edgemere	— 16930.407	— 55545.245	— 8919.955	— 29264.885
11	Enterprise	— 12872.336	— 42231.989	— 7109.091	— 23323.742
12	Far Rockaway schoolhouse	— 18411.750	— 60405.883	— 7544.167	— 24751.154
13	Forest Park	— 8921.480	— 29269.889	+ 2756.759	+ 9044.467
14	Flushing High School	— 12035.404	— 39486.154	+ 9541.083	+ 31302.703

BOROUGH OF QUEENS.

RECTANGULAR CO-ORDINATES—*Continued.*

Prospect Water Tower = Origin of Axes. True Meridian at Prospect Water Tower = Axis of Ordinates.

No.	Station.	X in Meters.	X in Feet.	Y in Meters.	Y in Feet.
*	Garden City cathedral	— 27489.050	— 90186.991	+ 5470.105	+ 17946.503
15	Golf	— 11170.548	— 36648.706	+ 4266.533	+ 13997.784
16	Grinnell	— 8379.650	— 27492.235	+ 9574.158	+ 31411.216
17	Hallock	— 21174.730	— 69470.759	+ 6174.980	+ 20259.080
18	Hollis	— 17063.051	— 55981.026	+ 5588.942	+ 18336.387
19	Hopedale	— 9711.300	— 31861.156	+ 6140.136	+ 20144.763
20	Idlewild	— 14650.273	— 48065.104	— 3763.066	— 12345.992
21	Jager	— 16988.139	— 55735.252	— 2404.724	— 7889.499
22	Lang	— 18410.061	— 60400.341	+ 2115.519	+ 6940.665
23	Life saving station, Rockaway Point	— 8679.778	— 28476.905	— 11367.832	— 37295.962
24	Long Island City High School	— 2562.096	— 8405.810	+ 8770.871	+ 28775.766
25	Lutheran 2	— 6655.962	— 21837.102	+ 4441.642	+ 14572.287
26	Miller	— 11952.727	— 39214.905	+ 6492.455	+ 21300.663
27	Metropolitan	— 16116.258	— 52874.756	+ 729.862	+ 2394.556
28	Newtown Heights	— 7531.260	— 24708.809	+ 6179.211	+ 20272.961
29	Normal	— 13872.401	— 45513.035	+ 4155.860	+ 13634.684

30	North Beach	— 7416.841	— 24333.419	+ 11374.777	+ 37318.747
31	O'Connell	— 13483.777	— 44238.025	+ 6987.207	+ 22923.861
32	Payne	— 20954.577	— 68748.474	+ 9498.865	+ 31163.996
33	Richmond Hill High School	— 11282.899	— 37017.311	+ 2573.808	+ 8444.235
34	Ridgewood gate house	— 6593.692	— 21632.804	+ 2028.822	+ 6656.227
35	Rockaway Point	— 5101.921	— 16738.552	— 12317.791	— 40412.619
36	Roeckel	— 20254.994	— 66453.259	+ 240.999	+ 790.678
37	Seaside Hotel	— 12117.670	— 39756.055	— 9724.307	— 31903.830
38	Sohmer	— 2714.059	— 8904.375	+ 10764.459	+ 35316.396
39	Schoolhouse No. 6	— 4128.286	— 13544.218	+ 9809.011	+ 32181.730
40	Schoolhouse No. 64	— 9345.242	— 30660.181	+ 1005.007	+ 3297.260
*	Spinney church	— 21380.339	— 70145.328	+ 12393.551	+ 40661.175
41	Spring Creek	— 9578.203	— 31424.487	— 2200.765	— 7220.343
42	Springfield schoolhouse	— 17629.849	— 57840.596	+ 18.514	+ 60.741
43	Steinway schoolhouse	— 5163.627	— 16940.999	+ 10971.768	+ 35996.542
44	Taylor	— 18203.326	— 59722.078	+ 9397.301	+ 30830.978
45	Van Sicklen	— 13085.669	— 42931.899	+ 1420.335	+ 4659.882
46	Weeks	— 14991.233	— 49183.736	+ 8511.560	+ 27925.009
47	Whitestone schoolhouse	— 12694.797	— 41649.513	+ 12643.872	+ 41482.436

* Garden City cathedral and Spinney church are in Nassau County, but are a part of the Queens triangulation.

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
1	Aqueduct schoolhouse.	40 39 57.626	1777^{m}.5 5831^{ft}.7	73 49 43.521	1022^{m}.3 3354^{ft}.0
2	Arverne Hotel	40 35 19.128	590^{m}.0 1935^{ft}.7	73 47 54.103	1272^{m}.3 4174^{ft}.2

QUEENS.

POSITIONS.

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
315 51 36.91	135 54 41.07	Far Rockaway school-house	9547^{m}.35 31323^{ft}.26	3.9798827
357 46 11.00	177 46 20.72	Seaside Hotel	9028^{m}.62 29621^{ft}.40	3.9556212
20 08 09.72	200 07 19.67	Duck Point	5246^{m}.33 17212^{ft}.33	3.7198558
50 45 00.68	230 39 16.93	Centennial tower	16037^{m}.27 52615^{ft}.61	4.2051304
54 08 16.38	234 05 47.90	Canarsie Park	6609^{m}.55 21684^{ft}.83	3.8201717
93 30 51.55	273 25 25.49	Prospect water tower	11773^{m}.08 38625^{ft}.51	4.0708899
140 48 11.52	320 46 53.08	Forest Park	4470^{m}.21 14666^{ft}.01	3.6503275
203 39 57.69	23 40 56.80	Normal	5301^{m}.43 17393^{ft}.11	3.7243928
220 15 27.87	40 17 55.70	Hollis	8253^{m}.85 27013^{ft}.89	3.9156030
79 01 25.53	259 00 24.06	Seaside Hotel	2263^{m}.29 7425^{ft}.48	3.3547597
98 52 08.23	278 49 45.96	Ruffle Bar 3	5204^{m}.00 17073^{ft}.46	3.7163373
146 11 00.68	326 10 20.21	Enterprise	2627^{m}.30 8619^{ft}.73	3.4195098
183 20 13.92	3 20 22.84	Idlewild	5534^{m}.80 18158^{ft}.76	3.7431018

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
2	Arverne Hotel—*Continued.*				
3	Bayhead Hotel.....	40 38 19.005	586^{m}.2 1923^{ft}.2	73 44 37.354	877^{m}.8 2879^{ft}.9
4	Bayside.....	40 46 29.666	915^{m}.1 3002^{ft}.3	73 47 07.631	178^{m}.9 586^{ft}.9

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
201	09	33.55	21	10	47.36	Jager	7376^{m}.57	3.8678546
							24201^{ft}.30	
246	55	10 62	66	57	03.45	Far Rockaway schoolhouse	4431^{m}.07	3.6465084
							14537^{ft}.60	
8	11	57.28	188	11	42.07	Far Rockaway schoolhouse	3851^{m}.83	3.5856670
							12637^{ft}.21	
48	53	28.58	228	50	19.01	Seaside Hotel	9089^{m}.96	3.9585618
							29822^{ft}.64	
89	42	34.88	269	40	35.67	Idlewild	4301^{m}.23	3.6335925
							14111^{ft}.62	
124	10	24.42	324	09	30.11	Jager	2368^{m}.86	3.3745398
							7771^{ft}.83	
131	25	55.91	311	23	13.53	Van Sicklen	7806^{m}.13	3.8924360
							25610^{ft}.61	
288	56	44.05	108	59	18.88	Payne	5880^{m}.52	3.7694159
							19293^{ft}.01	
344	02	09.30	164	02	55.54	Hollis	6044^{m}.08	3.7813299
							19829^{ft}.62	
7	57	46.15	187	57	34.93	Weeks	2912^{m}.15	3.4642140
							9554^{ft}.28	
23	29	03.31	203	28	10.07	O'Connell	4802^{m}.14	3.6815254
							15758^{ft}.30	
35	08	07.70	215	06	31.85	Miller	5987^{m}.91	3.7772749
							19645^{ft}.33	
61	09	45.81	241	08	12.36	Flushing High School	3832^{m}.35	3.5834646
							12573^{ft}.30	
152	01	37.88	332	00	21.50	Jackson	5840^{m}.86	3.7664767
							19162^{ft}.89	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
5	Belle Harbor church...	40 34 34.009	1049^{m}.0	73 50 55.255	1299^{m}.7
			3441^{ft}.6		4264^{ft}.1
6	Belmont.....	40 42 48.637	1500^{m}.3	73 43 33.915	796^{m}.0
			4922^{ft}.2		2611^{ft}.5
7	College Point school-house.....	40 47 08.329	256^{m}.9	73 50 47.417	1111^{m}.8
			842^{ft}.8		3647^{ft}.6

QUEENS.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
64 10 59.31	244 10 20.54	Rockaway Point life saving station	1557^{m}.17	3.1923352
			5108^{ft}.82	
158 04 45.08	338 04 20.67	Ruffle Bar 3	2363^{m}.18	3.3734964
			7753^{ft}.20	
213 29 55.10	33 32 01.91	Idlewild	8296^{m}.60	3.9189003
			27219^{ft}.76	
218 02 06.59	38 03 23.98	Enterprise	4538^{m}.82	3.6569427
			14881^{ft}.11	
244 45 51.92	64 46 48.30	Seaside Hotel	2253^{m}.43	3.3528434
			7393^{ft}.13	
251 53 36.00	71 55 33.84	Arverne Hotel	4482^{m}.04	3.6514760
			14704^{ft}.83	
39 13 28.59	219 12 32.60	Lang	3188^{m}.01	3.5035196
			10459^{ft}.33	
86 21 26.45	266 18 24.50	Normal	6561^{m}.27	3.8169879
			21526^{ft}.43	
106 43 17.49	286 41 44.28	Hollis	3501^{m}.49	3.5442528
			11487^{ft}.80	
186 22 56.87	6 23 12.14	Payne	4937^{m}.17	3.6934779
			16198^{ft}.03	
22 57 41.33	202 56 25.92	Newtown Heights	6947^{m}.82	3.8418488
			22794^{ft}.64	
39 12 15.01	219 07 30.24	Prospect water tower	16216^{m}.50	4.2099571
			53203^{ft}.63	
87 59 54.67	267 55 34.52	Memorial church	9343^{m}.71	3.9705192
			30655^{ft}.15	

GEOGRAPHICAL

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
7	College Point schoolhouse—*Continued.*				
8	Covert avenue schoolhouse.....	40 42 19.051	587^{m}.6 1927^{ft}.8	73 54 42.538	998^{m}.6 3276^{ft}.2
9	Consumers brewery...	40 44 23.327	719^{m}.5 2360^{ft}.6	73 54 27.046	634^{m}.5 2081^{ft}.7

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
179	24	32.19	359	24	31.22	Castle	3362^{m}.35	3.5266435
							11031^{ft}.31	
211	17	50.80	31	18	58.03	Jackson	4641^{m}.00	3.6666112
							15226^{ft}.35	
315	44	49.15	135	47	58.86	Hollis	9773^{m}.96	3.9900704
							32066^{ft}.73	
282	04	27.66	102	06	24.18	Forest Park	4290^{m}.18	3.6324750
							14075^{ft}.37	
311	00	56.94	131	01	48.79	Ridgewood gate house	2474^{m}.42	3.3934740
							8118^{ft}.16	
55	38	16.36	235	36	25.35	Schoolhouse No. 143	4830^{m}.05	3.6829515
							15846^{ft}.59	
5	25	10.99	185	25	00.86	Covert avenue schoolhouse	3850^{m}.67	3.5855361
							12633^{ft}.41	
25	45	41.98	205	44	43.70	Eppig brewery	4810^{m}.39	3.6821807
							15782^{ft}.09	
181	18	10.51	1	18	12.72	Steinway schoolhouse	3487^{m}.40	3.5425019
							11441^{ft}.58	
210	57	49.98	30	58	54.96	North Beach	4534^{m}.11	3.6564920
							14875^{ft}.66	
237	38	57.92	57	40	29.60	Grinnell	3899^{m}.63	3.5910229
							12794^{ft}.04	
298	09	09.88	118	10	17.83	Newtown Heights	2771^{m}.54	3.4427211
							9092^{ft}.96	
332	45	50.21	152	46	33.76	Lutheran 2	3424^{m}.30	3.5345724
							11234^{ft}.56	

BOROUGH OF

GEOGRAPHICAL

No	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
10	Edgemere Hotel.....	40 35 30.918	953^{m}.7	73 46 03.859	90^{m}.7
			3128^{ft}.9		297^{ft}.6
11	Enterprise.....	40 36 29.890	922^{m}.0	73 48 56.299	1323^{m}.6
			3024^{ft}.9		4342^{ft}.5
12	Far Rockaway school-house.....	40 36 15.407	475^{m}.2	73 45 00.719	16^{m}.9
			1559^{ft}.1		55^{ft}.4

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
75	39	31.76	255	36	22.19	Belle Harbor church	7074^{m}.24	3.8496800
							23209^{ft}.40	
80	38	31.82	260	36	18.62	Seaside Hotel	4879^{m}.48	3.6883739
							16008^{ft}.76	
93	15	45.30	273	12	11.28	Ruffle Bar 3	7746^{m}.57	3.8891096
							25415^{ft}.20	
114	10	42.92	294	08	50.69	Enterprise	4443^{m}.78	3.6477525
							14579^{ft}.30	
156	16	39.08	336	15	36.23	Idlewild	5638^{m}.48	3.7511624
							18498^{ft}.91	
180	38	16.60	0	38	18.63	Jager	6515^{m}.48	3.8139466
							21376^{ft}.20	
227	14	46.27	47	15	27.36	Far Rockaway school-house	2021^{m}.68	3.3057126
							6632^{ft}.80	
208	05	00.42	28	05	49.84	Idlewild	3789^{m}.05	3.5785303
							12431^{ft}.24	
241	02	00.82	61	04	49.41	Bayhead Hotel	6954^{m}.91	3.8422915
							22817^{ft}.90	
274	35	24.12	94	37	57.46	Far Rockaway school house	5556^{m}.48	3.7447997
							18229^{ft}.88	
16	11	43.63	196	11	22.62	Seaside Hotel	2721^{m}.92	3.4348761
							8930^{ft}.17	
71	02	12.08	250	59	17.78	Seaside Hotel	6660^{m}.97	3.8235872
							21853^{ft}.53	
80	14	47.01	260	05	59.49	Centennial tower	19350^{m}.68	4.2866963
							63486^{ft}.36	
112	25	22.49	292	16	52.46	Prospect water tower	19897^{m}.41	4.2987966
							65280^{ft}.09	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
13	Forest Park.....	40 41 49.919	1539^{m}.8 5051^{ft}.8	73 51 43.850	1029^{m}.5 3377^{ft}.6
14	Flushing High School..	40 45 29.715	916^{m}.6 3007^{ft}.2	73 49 30.750	721^{m}.3 2366^{ft}.5
15	Golf.....	40 42 38.765	1195^{m}.7 3922^{ft}.9	73 50 07.959	186^{m}.9 613^{ft}.2

QUEENS.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
72 53 51.09	252 49 43.38	Prospect water tower..	9337m.69	3.9702396
			30635ft.40	
157 57 41.61	337 57 03.10	Newtown Heights.....	3694m.03	3.5675009
			12119ft.50	
187 40 21.04	7 40 57.90	College Point school-house.....	9910m.66	3.9961027
			32515ft.22	
240 48 26 50	60 54 01.45	Payne..	13793m.13	4.1398627
			45252ft.96	
250 53 15.82	70 57 02.19	Hollis.....	8620m.12	3.9355134
			28281ft.18	
345 42 17.78	165 43 45.88	Seaside Hotel.....	12883m.81	4.1100442
			42268ft.63	
34 26 25.96	214 25 21.17	Hopedale.....	4119m.21	3.6148135
			13514ft.44	
90 36 40.94	270 34 59.19	Grinnell	3655m.90	3.5629947
			11994ft.40	
149 25 14.99	329 24 24.94	College Point school-house.....	3533m.54	3.5482099
			11592ft.96	
270 21 52.59	90 26 00.84	Payne.....	8919m.27	3.9503294
			29262ft.64	
341 15 27.18	161 16 18.01	Normal.....	5689m.92	3.7551060
			18667ft.68	
56 12 47.41	236 11 44.86	Forest Park.....	2708m.82	3.4327807
			8887ft.19	
117 48 39.63	297 46 58.55	Newtown Heights.....	4111m.30	3.6139787
			13488ft.49	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
15	Golf—*Continued.*				
16	Grinnell	40 45 30.951	954^{m}.7 3132^{ft}.2	73 52 06.600	154^{m}.8 507^{ft}.9
17	Hallock	40 43 39.928	1231^{m}.6 4040^{ft}.7	73 43 01.536	36^{m}.0 118^{ft}.1
18	Hollis	40 43 21.273	656^{m}.2 2152^{ft}.9	73 45 56.801	1333^{m}.0 4375^{ft}.4

QUEENS.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
142 10 23.25	322 09 42.76	Hopedale	2374m.82	3.3756315
			7791ft.39	
173 39 04.11	353 38 38.37	College Point schoolhouse	8366m.46	3.9225415
			27448ft.96	
257 26 14.35	77 28 58.19	Hollis	6039m.07	3.7809703
			19813ft.18	
272 25 55.22	92 27 10.29	Normal	2704m.12	3.4320254
			8871ft.77	
211 43 03.46	31 43 55.18	College Point schoolhouse	3531m.45	3.5479531
			11586ft.10	
294 43 02.07	114 47 03.41	Hollis	9554m.23	3.9801958
			31345ft.84	
314 40 25.61	134 42 58.14	Normal	7715m.46	3.8873616
			25313ft.14	
355 31 13.98	175 31 28.81	Forest Park	6838m.89	3.8349859
			22437ft.26	
14 05 43.77	194 05 20.07	Newtown Heights	3499m.34	3.5439867
			11480ft.75	
25 39 31.33	205 39 10.21	Belmont	1755m.18	3.2443214
			5758ft.45	
82 03 06.16	262 01 11.81	Hollis	4153m.23	3.6183863
			13626ft.06	
176 22 26.48	356 22 20.62	Payne	3331m.08	3.5225850
			10928ft.72	
354 16 05.44	174 16 41.97	Far Rockaway schoolhouse	13202m.16	4.1206451
			43314ft.09	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
18	Hollis—*Continued.*				
19	Hopedale	40 43 39.572	1220^{m}.6 4004^{ft}.6	73 51 10.021	235^{m}.2 771^{ft}.7
20	Idlewild	40 38 18.258	563^{m}.2 1847^{ft}.8	73 47 40.392	949^{m}.2 3114^{ft}.2

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
18	01	45.81	197	59	27.82	Seaside Hotel	16091^{m}.99	4.2066096
							52795^{ft}.14	
47	14	09.58	227	05	57.93	Centennial tower	24179^{m}.93	4.3834559
							79330^{ft}.48	
71	59	44.40	251	51	50.32	Prospect water tower	17955^{m}.06	4.2541868
							58907^{ft}.56	
112	29	46.94	292	22	16.35	Memorial church	17482^{m}.75	4.2426097
							57357^{ft}.99	
158	08	50.78	338	06	48.18	Jackson	11819^{m}.76	4.0726085
							38778^{ft}.66	
13	12	53.49	193	12	31.41	Forest Park	3474^{m}.34	3.5408726
							11398^{ft}.73	
61	00	17.42	240	58	52.43	Lutheran 2	3495^{m}.71	3.5435350
							11468^{ft}.84	
91	06	06.61	271	05	06.00	Newtown Heights	2180^{m}.39	3.3385342
							7153^{ft}.50	
158	52	46.56	338	52	09.63	Grinnell	3683^{m}.18	3.5662224
							12083^{ft}.90	
184	42	17.99	4	42	32.76	College Point schoolhouse	6461^{m}.22	3.8103148
							21198^{ft}.19	
274	21	45.44	94	25	09.80	Hollis	7372^{m}.39	3.8676081
							24187^{ft}.58	
295	34	11.33	115	36	06.90	Normal	4610^{m}.00	3.6637012
							15124^{ft}.64	
23	07	50.84	203	06	40.42	Seaside Hotel	6476^{m}.91	3.8113679
							21249^{ft}.66	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
20	Idlewild--*Continued.*				
21	Jager.....	40 39 02.133	65^{m}.8 215^{ft}.9	73 46 00.772	18^{m}.1 59^{ft}.4

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
49	09	43.79	229	07	12.53	Ruffle Bar 3	7229^{m}.36	3.8586793
							23695^{ft}.36	
68	25	02.02	248	22	51.83	Duck Point	5054^{m}.54	3.7036815
							16583^{ft}.10	
84	25	53.61	264	22	05.01	Canarsie Park	8289^{m}.38	3.9185218
							27196^{ft}.07	
104	31	06.18	284	24	20.01	Prospect water tower	15125^{m}.84	4.1797196
							49625^{ft}.36	
136	40	04.84	316	38	44.65	Aqueduct schoolhouse	4214^{m}.63	3.6247594
							13827^{ft}.50	
194	34	46.23	14	35	53.78	Hollis	9658^{m}.23	3.9848976
							31687^{ft}.04	
239	57	19.55	59	58	24.47	Jager	2703^{m}.83	3.4319793
							8870^{ft}.82	
315	15	42.58	135	17	26.54	Far Rockaway schoolhouse	5333^{m}.43	3.7270064
							17498^{ft}.09	
344	38	53.34	164	39	32.42	Far Rockaway schoolhouse	5332^{m}.96	3.7269686
							17496^{ft}.55	
33	46	14.70	213	43	59.40	Seaside Hotel	8791^{m}.90	3.9440828
							28844^{ft}.76	
108	08	02.96	288	05	37.83	Aqueduct schoolhouse	5505^{m}.64	3.7408077
							18063^{ft}.09	
134	33	25.06	314	31	37.00	Van Sicklen	5464^{m}.46	3.7375471
							17927^{ft}.98	
180	40	04.44	0	40	07.03	Hollis	7994^{m}.01	3.9027647
							26227^{ft}.01	

BOROUGH OF

GEOGRAPHICAL

No.	Stations.	Latitude. °	′	″	Length of Seconds.	Longitude. °	′	″	Length of Seconds.
22	Lang.....	40	41	28.565	$881^{m}.1$ $2890^{ft}.7$	73	44	59.774	$1403^{m}.5$ $4604^{ft}.6$
23	Life saving station, Rockaway Point..	40	34	12.019	$370^{m}.7$ $1216^{ft}.2$	73	51	54.846	$1290^{m}.1$ $4232^{ft}.6$
24	Long Island City High School.....	40	45	05.048	$155^{m}.7$ $510^{ft}.8$	73	56	14.625	$343^{m}.1$ $1125^{ft}.7$

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
17	36	14.10	197	35	34.35	Jager	4738^{m}.61	3.6756507
							15546^{ft}.59	
82	42	11.58	262	39	43.71	Van Sicklen	5369^{m}.59	3.7299407
							17616^{ft}.73	
114	21	09.99	294	19	04.07	Normal	4975^{m}.23	3.6968171
							16325^{ft}.06	
158	56	43.79	338	56	06.60	Hollis	3725^{m}.47	3.5711807
							12222^{ft}.65	
199	09	27.71	19	10	38.99	Payne	7809^{m}.42	3.8926189
							25621^{ft}.41	
75	11	49.60	255	10	10.68	Rockaway Point	3701^{m}.82	3.5684152
							12145^{ft}.05	
129	27	04.45	309	26	12.83	Barren Island schoolhouse	2416^{m}.97	3.3832708
							7929^{ft}.68	
127	02	36.71	307	00	08.63	Avenue U	6704^{m}.01	3.8263347
							21994^{ft}.74	
161	30	15.86	341	29	12.99	Canarsie Park	7156^{m}.46	3.8546982
							23479^{ft}.15	
190	14	52.55	10	15	06.92	Ruffle Bar 3	2917^{m}.10	3.4649507
							9570^{ft}.52	
244	30	58.03	64	32	33.17	Seaside Hotel	3810^{m}.55	3.5809874
							12501^{ft}.78	
20	00	47.64	200	00	06.82	Schoolhouse No. 143	4272^{m}.04	3.6306349
							14015^{ft}.85	
154	21	49.71	334	21	03.33	Memorial church	3849^{m}.73	3.5854301
							12630^{ft}.32	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
24	Long Island City High School—*Continued.*				
25	Lutheran 2.....	40 42 44.618	1376^{m}.2 4515^{ft}.1	73 53 20.280	476^{m}.0 1561^{ft}.7
26	Miller.....	40 43 50.887	1569^{m}.5 5149^{ft}.3	73 49 34.484	809^{m}.3 2655^{ft}.2

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″		′	″			
184	22	43.75	4	22	48.00	Sohmer	1999^{m}.37	3.3008934
							6559^{ft}.60	
229	47	17.87	49	48	30.32	Steinway schoolhouse	3407^{m}.62	3.5324506
							11179^{ft}.83	
297	00	25.79	117	01	36.01	Consumers brewery	2833^{m}.12	3.4522644
							9294^{ft}.99	
337	06	35.75	157	07	35.82	Covert ave. schoolhouse.	5557^{m}.76	3.7448997
							18234^{ft}.08	
355	34	28.60	175	34	40.51	Eppig brewery	5636^{m}.33	3.7509962
							18491^{ft}.86	
206	47	16.71	26	47	41.10	Newtown Heights	1945^{m}.58	3.2890497
							6383^{ft}.12	
306	41	23.36	126	42	26.25	Forest Park	2823^{m}.37	3.4507673
							9263^{ft}.01	
1	31	46.22	181	31	44.44	Ridgewood gate house	2413^{m}.63	3.3826704
							7918^{ft}.72	
67	47	26.75	247	46	33.10	Covert avenue schoolhouse	2085^{m}.77	3.3192660
							6843^{ft}.06	
19	27	12.90	199	26	51.06	Golf	2359^{m}.35	3.3727927
							7740^{ft}.63	
39	08	56.82	219	07	32.42	Forest Park	4810^{m}.81	3.6822183
							15783^{ft}.47	
81	09	33.47	261	08	31.13	Hopedale	2268^{m}.95	3.3558249
							7444^{ft}.05	
181	38	44.57	1	38	47.00	Flushing High School	3049^{m}.74	3.4842628
							10005^{ft}.69	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
26	Miller—*Continued.*				
27	Metropolitan	40 40 43.816	1351^{m}.5	73 46 37.592	882^{m}.8
			4434^{ft}.0		2896^{ft}.3
28	Newtown Heights	40 43 40.921	1262^{m}.2	73 52 42.916	1007^{m}.1
			4141^{ft}.1		3304^{ft}.1

QUEENS.

POSITIONS – *Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
280 07 06.96	100 09 28.99	Hollis	5189^{m}.58	3.7151323
			17026^{ft}.15	
320 41 13.16	140 42 06.40	Normal	3024^{m}.01	3.4805881
			9921^{ft}.37	
18 11 42.39	198 11 01.43	Idlewild	4726^{m}.04	3.6744977
			15505^{ft}.55	
102 57 32.97	282 56 08.87	Van Sicklen	3108^{m}.25	3.4925164
			10197^{ft}.65	
105 51 27.89	285 48 08.20	Forest Park	7474^{m}.84	3.8736017
			24523^{ft}.70	
146 54 04.91	326 53 02.78	Normal	4095^{m}.40	3.6122966
			13436^{ft}.32	
191 09 00.89	11 09 27.49	Hollis	4950^{m}.46	3.6946457
			16241^{ft}.63	
209 00 44.60	29 02 59.67	Payne	10015^{m}.15	4.0006574
			32858^{ft}.04	
228 13 27.11	48 15 26.86	Belmont	5781^{m}.16	3.7620151
			18967^{ft}.02	
238 59 19.10	59 00 22.86	Lang	2679^{m}.85	3.4281099
			8792^{ft}.14	
276 51 38.98	96 53 33.81	Roeckel	4167^{m}.51	3.6198763
			13672^{ft}.91	
344 34 49.68	164 35 13.67	Jager	3253^{m}.58	3.5123611
			10674^{ft}.45	
50 41 24.35	230 37 55.07	Prospect water tower	9741^{m}.79	3.9886389
			31961^{ft}.19	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
28	Newtown Heights—*Continued.*				
29	Normal	40 42 35.029	1080^{m}.5 3544^{ft} 9	73 48 12.865	302^{m}.0 990^{ft}.8
30	North Beach	40 46 29.357	905^{m}.5 2970^{ft}.8	73 52 47.570	1115^{m}.5 3659^{ft}.8
31	O'Connell	40 44 06.841	211^{m}.0 692^{ft}.3	73 48 29.201	685^{m}.2 2248^{ft}.0

QUEENS.

POSITIONS—*Continued.*

Azimuth			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
132	28	09.70	312	25	05.12	Memorial church.....	8987^{m}.87	3.9536567
							29487^{ft}.70	
206	16	38.80	26	19	01.42	Jackson.....	11559^{m}.39	4.0629348
							37924^{ft}.43	
273	36	06.10	93	40	31.06	Hollis.....	9550^{m}.05	3.9800058
							31332^{ft}.12	
74	19	37.72	254	17	20.11	Forest Park.....	5144^{m}.81	3.7113692
							16879^{ft}.26	
156	44	29.94	336	42	49.07	College Point schoolhouse	9176^{m}.99	3.9627002
							30108^{ft}.17	
233	04	31.72	53	07	49.02	Payne.....	8871^{m}.54	3.9479989
							29106^{ft}.04	
245	55	10.91	65	56	39.67	Hollis.....	3497^{m}.72	3.5437849
							11475^{ft}.44	
97	37	25.75	277	34	24.09	Memorial church.....	6578^{m}.82	3.8181477
							21584^{ft}.01	
160	17	01.72	340	16	03.74	Morris High School.....	6163^{m}.07	3.7897969
							20220^{ft}.01	
225	18	58.25	45	21	23.96	Jackson.....	7351^{m}.10	3.8663525
							24117^{ft}.73	
246	52	55.60	66	54	14.08	College Point schoolhouse	3063^{m}.20	3.4861750
							10049^{ft}.85	
331	55	24.54	151	55	51.26	Grinnell.....	2041^{m}.87	3.3100280
							6699^{ft}.04	
251	31	19.88	71	34	47.88	Payne	7881^{m}.68	3.8966187
							25858^{ft}.48	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
31	O'Connell—*Continued.*				
32	Payne	40 45 27.701	854^{m}.5 2803^{ft}.5	73 43 10.517	246^{m}.7 809^{ft}.4
33	Richmond Hill High School,.....	40 41 43.884	1353^{m}.6 4440^{ft}.9	73 50 03.282	77^{m}.1 253^{ft}.0

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
291	26	32.89	111	28	12.32	Hollis	3842^{m}.70	3.5846366
							12607^{ft}.26	
352	17	19.62	172	17	30.27	Normal	2857^{m}.90	3.4560472
							9376^{ft}.29	
40	28	35.99	220	27	31.55	Golf	3571^{m}.15	3.5528082
							11716^{ft}.55	
72	11	45.69	252	11	03.09	Miller	1609^{m}.00	3.2065570
							5278^{ft}.86	
150	32	42.93	330	32	02.78	Flushing High School	2935^{m}.99	3.4677543
							9632^{ft}.49	
45	01	38.55	224	59	50.03	Hollis	5516^{m}.41	3.7416567
							18098^{ft}.42	
76	16	17.01	256	10	03.43	Newtown Heights	13827^{m} 69	4.1407496
							45366^{ft}.35	
106	11	48.82	286	06	50.46	College Point school-house	11155^{m}.75	4.0474988
							36600^{ft}.16	
130	27	10.32	310	23	19 05	Jackson	10902^{m}.73	4.0375351
							35770^{ft}.04	
94	31	01.85	274	29	56.27	Forest Park	2368^{m}.50	3.3744731
							7770^{ft}.65	
176	17	22.56	356	17	19.51	Golf	1696^{m}.45	3.2295411
							5565^{ft}.77	
238	39	51.61	58	41	03.63	Normal	3034^{m}.53	3.4820911
							9955^{ft}.79	
242	32	19.96	62	35	00.74	Hollis	6519^{m}.29	3.8142006
							21388^{ft}.70	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
33	Richmond Hill High School—*Continued.*				
*	Richmond Hill High School dome.....	40 41 44.025	1358m.0	73 50 03.447	80m.9
34	Ridgewood gate house.	40 41 26.399	814m.3	73 53 23 024	540m.6
			2671ft.6		1773ft.6
35	Rockaway Point.....	40 33 41.328	1274m.8	73 54 26.976	634m.6
			4182ft.4		2082ft.0

*This dome is not a part of the triangulation, but its geographical position was determined on account of its being an astronomical observatory.

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
302	41	58 17	122	42	48.19	Van Sicklen.....	2140^{m}.20	3.3304554
							7021^{ft}.64	
351	56	21.20	171	56	34.09	Aqueduct schoolhouse..	3310^{m}.31	3.5198688
							10860^{ft}.58	
309	03	33.61	129	09	00.80	Far Rockaway schoolhouse.....	15208^{m}.83	4 1820959
							49897^{ft}.64	
334	52	38.17	154	55	10.84	Seaside Hotel.....	12986^{m}.54	4.1134934
							42606^{ft}.67	
252	41	07.32	72	42	11.98	Forest Park.....	2438^{m}.94	3.3872020
							8001^{ft}.76	
29	22	22.58	209	19	01.68	Centennial tower.....	14793^{m}.72	4.1700773
							48535^{ft}.73	
72	56	53.40	252	53	50.35	Prospect water tower....	6898^{m}.76	3.8387711
							22633^{ft}.68	
104	10	09.51	284	07	30.46	Centennial tower.....	5932^{m}.48	3.7732361
							19463^{ft}.48	
122	41	39.07	302	39	27.10	Ocean Parkway, South base.....	5669^{m}.07	3.7535115
							18599^{ft}.27	
160	24	05.46	340	23	16.36	Avenue U.....	5290^{m}.05	3.7234601
							17355^{ft}.77	
189	34	42.59	9	35	18.71	Canarsie Park.....	7842^{m}.57	3.8944584
							25730^{ft}.16	
214	35	01.93	34	35	49.26	Barren Island schoolhouse.....	3015^{m}.21	3.4793172
							9892^{ft}.40	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
35	Rockaway Point—*Continued.*				
36	Roeckel.....	40 40 27.639	852^{m}.6 2797^{ft}.2	73 43 41.418	972^{m}.8 3191^{ft}.6
37	Seaside Hotel.....	40 35 05.146	158^{m}.7 520^{ft}.7	73 49 28.580	672^{m}.2 2205^{ft}.4
38	Sohmer.....	40 46 09.676	298^{m}.4 979^{ft}.0	73 56 08.116	190^{m}.3 624^{ft}.3

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
249	45	05.82	69	48	19.89	Seaside Hotel	7479^{m}.76	3.8738879
							24539^{ft}.85	
13	28	34.84	193	27	43.17	Far Rockaway schoolhouse	8000^{m}.37	3.9031101
							26247^{ft}.88	
51	09	12.10	231	07	41.30	Jager	4203^{m}.82	3.6236445
							13792^{ft}.03	
121	40	46.72	301	37	49.72	Normal	7487^{m}.57	3.8743407
							24565^{ft}.47	
135	36	43.16	315	35	52.08	Lang	2630^{m}.14	3.4199781
							8629^{ft}.05	
149	19	30.62	329	18	02.34	Hollis	6228^{m}.08	3.7943543
							20433^{ft}.29	
84	58	04.96	264	52	11.78	Centennial tower	12819^{m}.99	4.1078877
							42060^{ft}.25	
128	50	23.58	308	44	48.07	Prospect water tower	15537^{m}.05	4.1913686
							50974^{ft}.47	
129	05	34.64	309	04	44.00	Memorial church	2342^{m}.70	3 3697173
							7686^{ft}.01	
202	14	08.02	22	15	21.10	Morris High School	6923^{m}.93	3.8403528
							22716^{ft}.26	
262	37	35.28	82	39	46.27	North Beach	4742^{m}.20	3.6759802
							15558^{ft}.37	
265	11	00.00	85	12	08.21	Steinway schoolhouse	2458^{m}.31	3.3906363
							8065^{ft}.31	
324	08	02.09	144	09	08.07	Consumers brewery	4047^{m}.57	3.6071946
							13279^{ft}.40	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
39	Schoolhouse No. 6.....	40 45 38.680	1193^{m}.1	73 55 07.838	183^{m}.8
			8914^{ft}.4		603^{ft}.0
40	Schoolhouse No. 64....	40 40 53.112	1638^{m}.3	73 51 25.897	608^{m}.2
			5375^{ft}.0		1995^{ft}.4
41	Spring Creek.....	40 39 09.174	283^{m}.0	73 51 16.151	379^{m}.4
			928^{ft}.5		1244^{ft}.7

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
56	29	37.59	236	28	53.98	Long Island City High School	1879^{m}.01	3.2739295
							6164^{ft}.72	
124	04	29.29	304	03	49.92	Sohmer	1706^{m}.73	3.2321642
							5599^{ft} 50	
221	42	49.49	41	43	18.33	Steinway schoolhouse	1556^{m}.89	3.1922588
							5107^{ft} 90	
244	34	16.96	64	35	48.56	North Beach	3642^{m}.27	3.5613722
							11949^{ft}.68	
337	37	07.76	157	37	34.37	Consumers brewery	2513^{m}.67	3.4003091
							8246^{ft}.93	
64	20	12 64	244	19	40.20	Atkins avenue schoolhouse	2095^{m}.80	3.3213503
							6875^{ft}.97	
166	28	22.89	346	28	11.18	Forest Park	1802^{m}.28	3.2558220
							5912^{ft}.98	
231	04	37.83	51	05	31.69	Richmond Hill High School	2493^{m}.12	3.3967435
							8179^{ft}.51	
305	26	06.03	125	27	12.75	Aqueduct schoolhouse	2951^{m}.34	3.4700187
							9682^{ft}.85	
355	54	56.35	175	55	02.70	Spring Creek	3214^{m}.23	3.5070766
							10545^{ft}.35	
235	30	32.36	55	31	32.71	Aqueduct schoolhouse	2639^{m}.83	3.4215755
							8660^{ft}.84	
353	49	34.19	173	49	44.47	Duck Point	3451^{m}.34	3.5379874
							11323^{ft}.27	
53	11	54.78	233	10	26.65	Canarsie Park	3971^{m}.01	3.5989010
							13028^{ft}.22	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
42	Springfield schoolhouse	40 40 20.643	$636^{m}.8$	73 45 33.214	$780^{m}.1$
			$2089^{ft}.2$		$2559^{ft}.4$
43	Steinway schoolhouse..	40 46 16.354	$504^{m}.4$	73 51 23.664	$554^{m}.9$
			$1654^{ft}.9$		1820^{ft} 5
44	Taylor.....	40 45 24.647	$760^{m}.3$	73 45 07.817	$183^{m}.4$
			$2494^{ft}.4$		$601^{ft}.7$

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms.
°	′	″	°	′	″			
38	22	16.23	218	20	53.35	Idlewild	4814^{m}.37	3.6825393
							15795^{ft}.15	
137	53	26.91	317	51	42.81	Normal	5588^{m}.92	3.7473279
							18336^{ft}.31	
174	19	33.76	354	19	18.38	Hollis	5559^{m}.19	3.7481252
							18370^{ft}.01	
200	32	39.02	20	33	00.81	Lang	2237^{m}.45	3.3497525
							7340^{ft}.70	
211	31	20.24	31	32	38.02	Belmont	5355^{m}.91	3.7288331
							17571^{ft}.85	
265	17	29.99	85	18	42.85	Roeckel	2634^{m}.56	3.4207074
							8643^{ft}.55	
106	36	03.48	286	34	04.62	Memorial church	4453^{m}.05	3.6486572
							14609^{ft}.71	
181	35	36.58	1	35	41.41	Morris High School	6204^{m}.97	3.7927394
							20357^{ft}.47	
259	53	57.29	79	55	00.08	North Beach	2288^{m}.97	3.3596406
							7509^{ft}.73	
293	31	42.88	113	33	12.38	Grinnell	3506^{m}.58	3.5448843
							11504^{ft}.50	
333	44	57.97	153	46	03.73	Newtown Heights	5345^{m}.49	3.7279877
							17537^{ft}.66	
268	01	41.73	88	02	58.31	Payne	2753^{m}.12	3.4398256
							9032^{ft}.53	
16	48	32.37	196	48	00.40	Hollis	3975^{m}.40	3.5993811
							13042^{ft}.62	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
44	Taylor—*Continued.*				
45	Van Sicklen.....	40 41 06.394	197^{m}.2 647^{ft}.0	73 48 46.586	1093^{m}.9 3588^{ft}.9
46	Weeks.....	40 44 56.165	1732^{m}.5 5684^{ft}.0	73 47 24.827	582^{m}.4 1910^{ft} 8
47	Whitestone schoolhouse	40 47 10.267	316^{m}.7 1039^{ft}.0	73 49 02.413	56^{m}.6 185^{ft}.7

QUEENS.

POSITIONS—*Continued.*

Azimuth.	Back Azimuth.	To Stations.	Distance.	Logarithms.
° ′ ″	° ′ ″			
74 43 27.29	254 41 57.86	Weeks	333 m.98	3.5227022
			10931ft.67	
125 31 32.12	305 30 13.89	Bayside	3452m.38	3.5381186
			11326ft.68	
142 15 13.08	323 12 38.44	Jackson	9061m.99	3.9572237
			29730ft.88	
32 13 53.92	212 13 16.81	Aqueduct schoolhouse	2507m.48	3.3992370
			8226ft.62	
107 53 38.53	287 51 42.95	Forest Park	4373m.39	3.6408179
			14348ft.36	
196 08 45.69	16 09 07.68	Normal	2846m.40	3.4542958
			9338 t.56	
223 45 22.28	43 47 13.01	Hollis	5761m.67	3.7605485
			18903ft.08	
329 23 05.93	149 25 33.04	Far Rockaway schoolhouse	10427m.34	4.0181734
			34210ft.36	
260 42 56.86	80 45 42.87	Payne	6044m 51	3.7813609
			19831ft.03	
324 46 59.69	144 47 57.13	Hollis	3582m.47	3.5541830
			11753 t.49	
44 47 47.07	224 47 05.05	O'Connell	2143m.85	3 3311935
			7033f .61	
109 19 08.40	289 17 46.18	Flushing High School	3129m.99	3.4955427
			10268ft.98	
290 56 36.36	111 00 26.16	Payne	8838m.29	3.9463684
			28996ft.96	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
47	Whitestone schoolhouse—*Continued.*				

QUEENS.

POSITIONS—*Continued.*

Azimuth.			Back Azimuth.			To Stations.	Distance.	Logarithms
°	′	″	°	′	″			
294	56	40.64	114	57	55.60	Bayside	2968^{m}.66	3.4725598
							9739^{ft}.68	
12	05	45.34	192	05	23.83	Flushing High School	3172^{m}.08	3.5013445
							10407^{ft}.07	
88	37	06.68	268	35	58.10	College Point school house	2462^{m}.76	3.3914225
							8079^{ft}.91	
142	55	30.76	322	54	21.18	Castle	4139^{m}.64	3.6169630
							13581^{ft}.47	
179	16	09.00	359	16	07.61	Jackson	3905^{m}.79	3.5917086
							12814^{ft}.25	

DESCRIPTION OF STATIONS—BOROUGH OF QUEENS.

AQUEDUCT SCHOOLHOUSE.

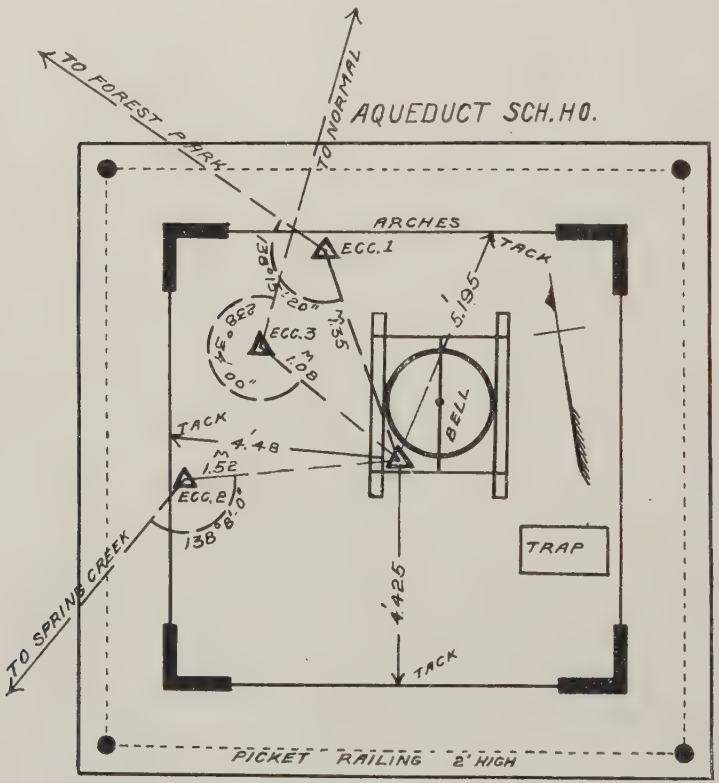
This station is the flagpole on the bell tower of Public School No. 46, Aqueduct, Borough of Queens, New York City, N. Y.

The building is of brick, 2½ stories high. Above this is a square wooden tower surmounted by a pyramidal cupola. The flagpole projects through this cupola. The roof of the tower is flat, of tin. The bell is in the center. The pole does not come through to the roof but is supported on a beam underneath the roof of the cupola. The point was dropped by a transit on the ground, and is marked with a brass nail around which a triangle is cut. The cupola is open, having four wide arches.

Three eccentrics were established, one for primary and the others for secondary stations.

The point is referenced by three brass tacks in arches. See sketch.

Reached by L. I. R. R. from Flatbush avenue, Brooklyn to Aqueduct.



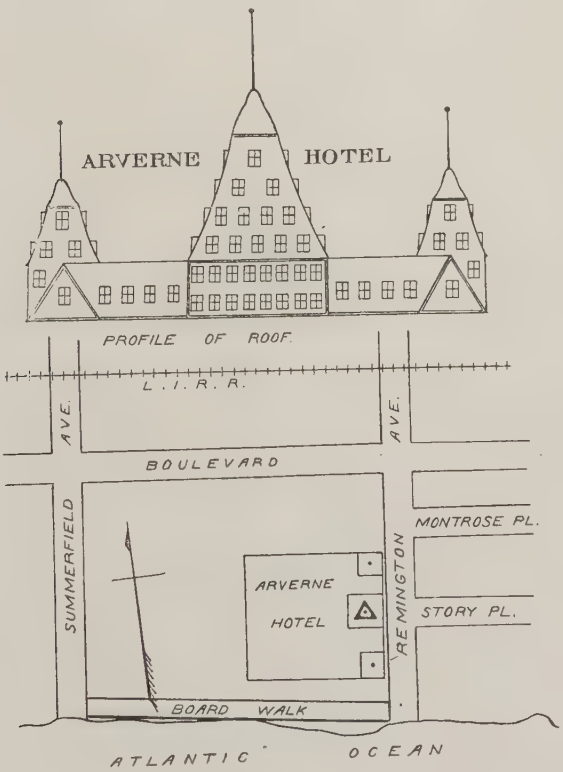
ARVERNE HOTEL.

Station Arverne Hotel is the base of the pole on the largest of the three towers on Arverne Hotel, corner of Boulevard and Remington avenue, Arverne, Borough of Queens, New York City, N. Y.

The largest tower is in the center, the smaller ones at either end.

The building is of wood, painted cream color. The roof and towers are a natural wood color. The towers contain a number of dormer windows up the sides which, at a distance, give them a corrugated appearance.

Reached by L. I. R. R. to Arverne.



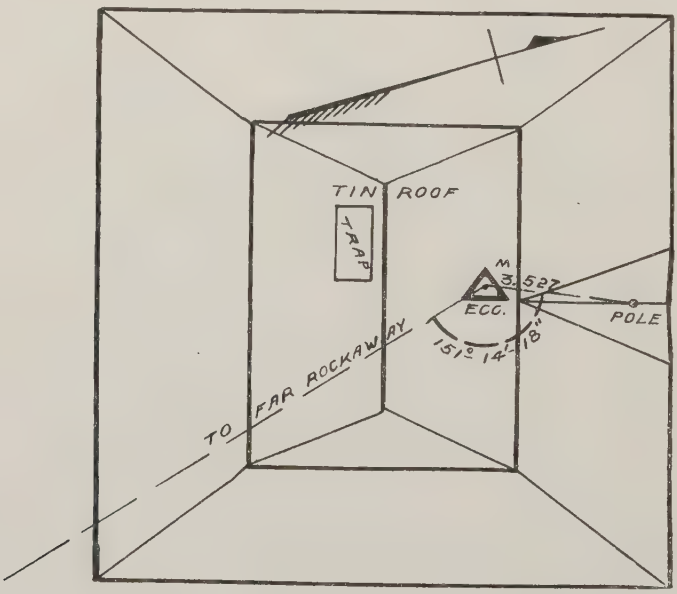
BAYHEAD HOTEL.

This station is the flagpole on Bayhead Hotel, Rockaway road, Head of the Bay, near Far Rockaway, Borough of Queens, New York City, N. Y.

The building is of wood, painted yellow, with black mansard roof. In the center is a rectangular platform with flat tin roof, from which observations were taken. The station is easily identified by three dormer windows on the sides.

Reached by Far Rockaway trolley from Jamaica which passes the station.

BAYHEAD HOTEL



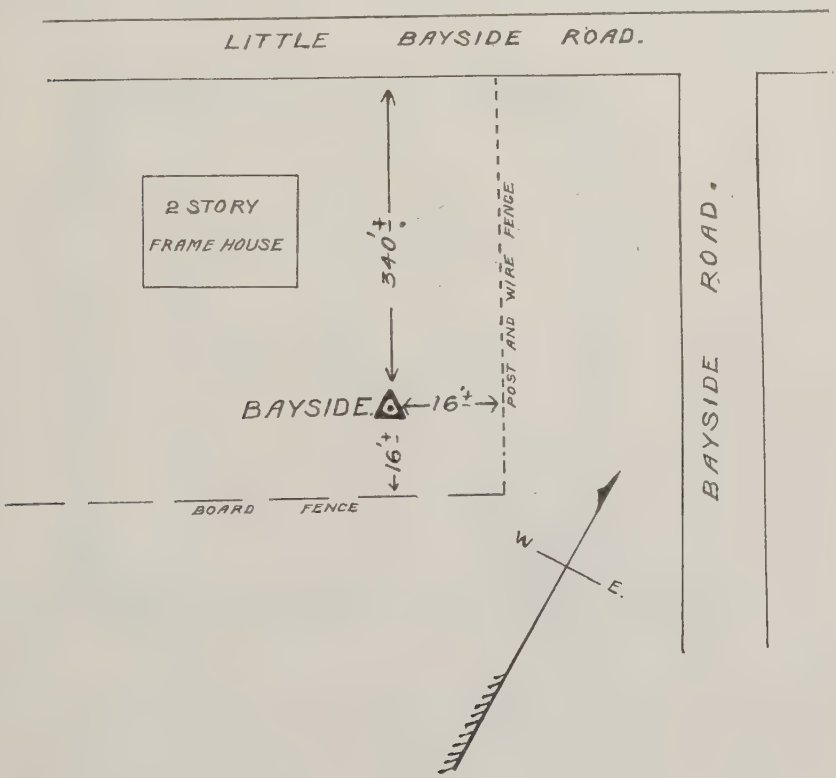
BAYSIDE.

This station consists of a 68-foot tripod and scaffold on the farm of Mr. G. H. Leavitt at Bayside, Borough of Queens, New York City, N. Y.

The property is leased to Mr. Vincent Newman, who lives on the grounds.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by L. I. R. R. from Long Island City to Bayside, then by carriage to station.

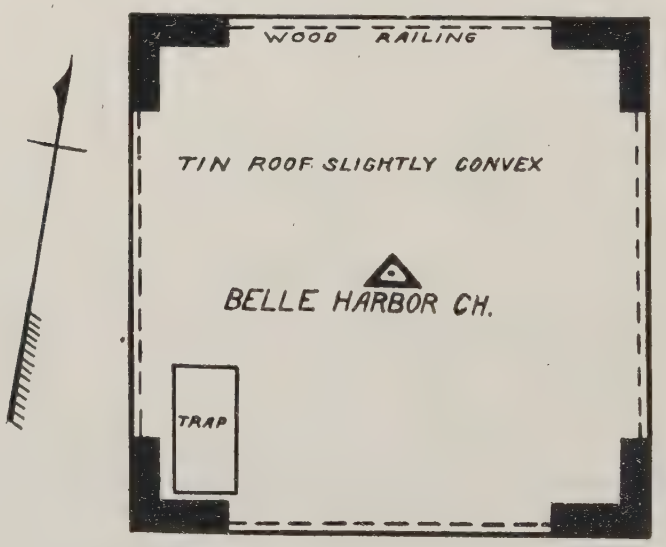


BELLE HARBOR CHURCH.

This station is the cross on the spire of St. Francis de Sales Roman Catholic Church, Chester and Washington avenues, Belle Harbor, Rockaway Beach, Borough of Queens, New York City, N. Y.

The building is wooden, painted green. The spire is square for about half its height where it contains an open platform with wide heavy arches. It was on this platform the observations were taken. The point was marked by a brass tack.

Reached by L. I. R. R. to Rockaway Park.

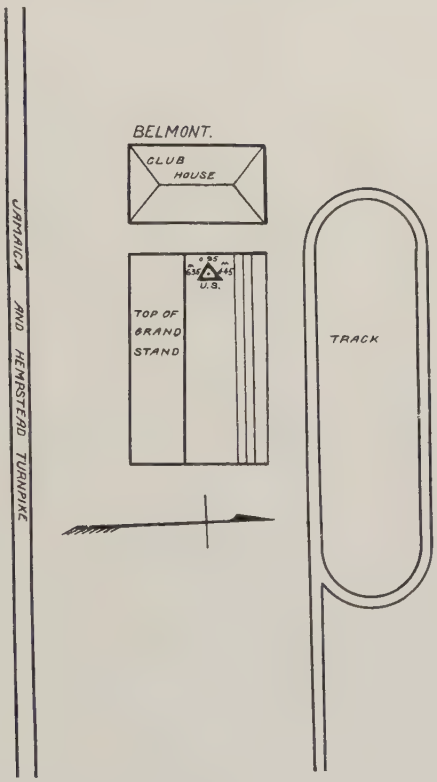


BELMONT.

This station is a point on the highest part of the grand stand of the Belmont Race Track, near Floral Park, L. I., and just east of the easterly line of Queens Borough, New York City, N. Y.

The point is on the concrete floor of the highest row of seats near the westerly edge and is at present marked by a large cross (+) cut in the concrete, with U. S. cut in the concrete alongside it, U+S.

Station is reached by L. I. R. R. from Long Island City, or from Flatbush avenue, Brooklyn, to Floral Park, thence walking southwest to Belmont.

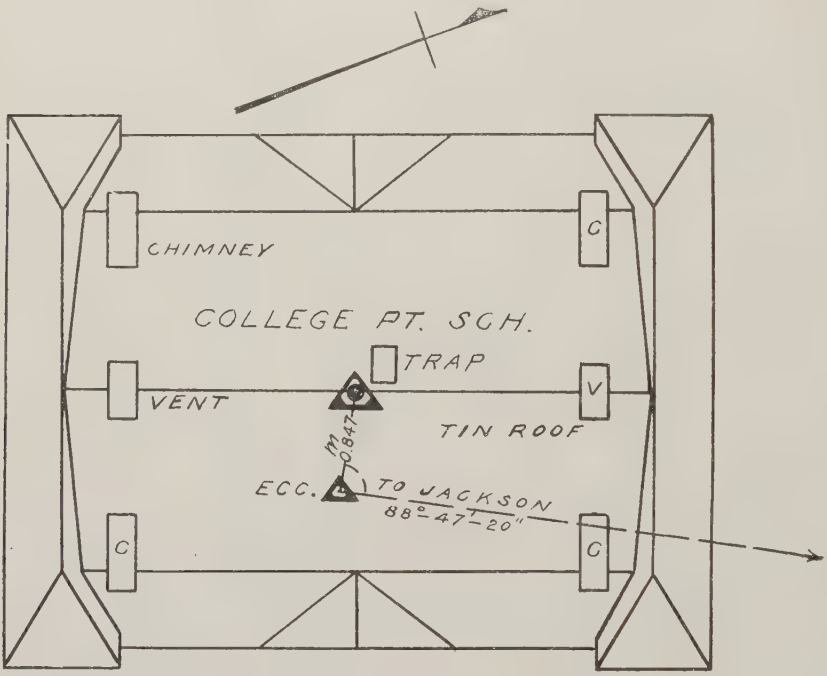


COLLEGE POINT SCHOOLHOUSE.

This station is the flagpole of the College Point Schoolhouse which is situated at the corner of First avenue and Thirteenth street, College Point, Borough of Queens, New York City, N. Y.

The pole is approximately in the center of a large tin roof, which is almost flat. The view is obstructed in many directions by large chimneys at the ends of the roof.

Access to roof is by means of scuttle near base of pole.

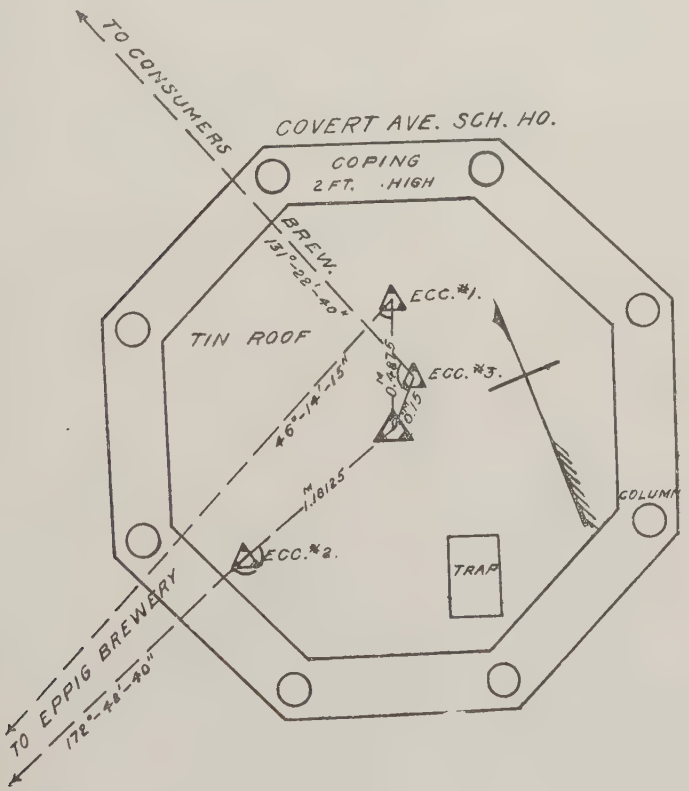


COVERT AVENUE SCHOOLHOUSE.

This station is the flagpole on Public School No. 75, Covert avenue to Bleecker street, Ridgewood, Borough of Queens, New York City, N. Y.

The building is two stories high, built of red brick, with a mansard slate roof. The roof is surmounted by an octagonal wooden cupola having a red roof. This cupola has a platform near the roof and the center was fixed with a transit located on the ground. A brass tack marks the point. The floor is of tin.

Reached by Ridgewood elevated train to Ridgewood; walk down Wyckoff avenue to Bleecker street, thence through Bleecker street to school.



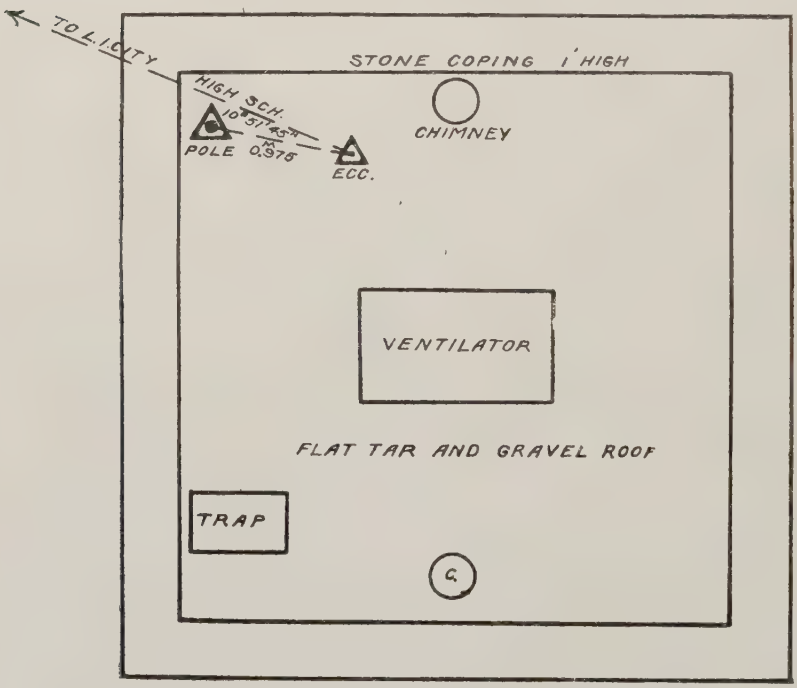
CONSUMERS' BREWERY.

This station is the flagpole on the roof of Consumers' Brewing Co. of Brooklyn, located on Betts avenue, 500 feet ± south of Thomson avenue, Woodside, Borough of Queens, New York City, N. Y.

The building is of red brick about 130 feet high, square, flat tar and gravel roof. The flagpole is in the northwest corner of the roof.

Reached by Corona trolley from Long Island City to Winfield.

CONSUMERS BREWERY.

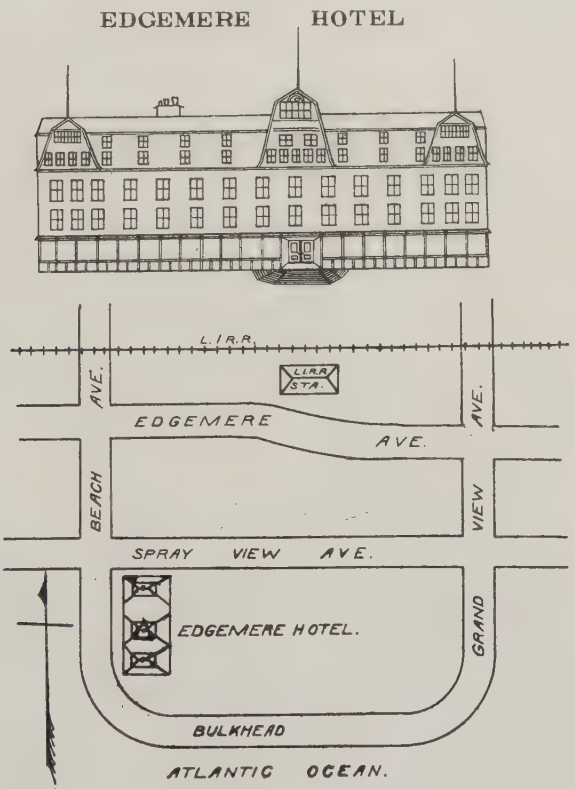


EDGEMERE HOTEL.

Station Edgemere Hotel is the base of the pole on the largest of three towers on Edgemere Hotel, corner of Beach and Spray View avenues, Edgemere, Borough of Queens, New York City, N. Y.

The building is wooden and of a natural wood color. The poles are white and small in size. The two smaller towers come about even with the roof and have more the appearance of large dormer windows. The large tower is rectangular in shape and is higher than the main roof. It is not exactly in the center of the building, being nearer the southerly end.

Reached by L. I. R. R. to Edgemere.

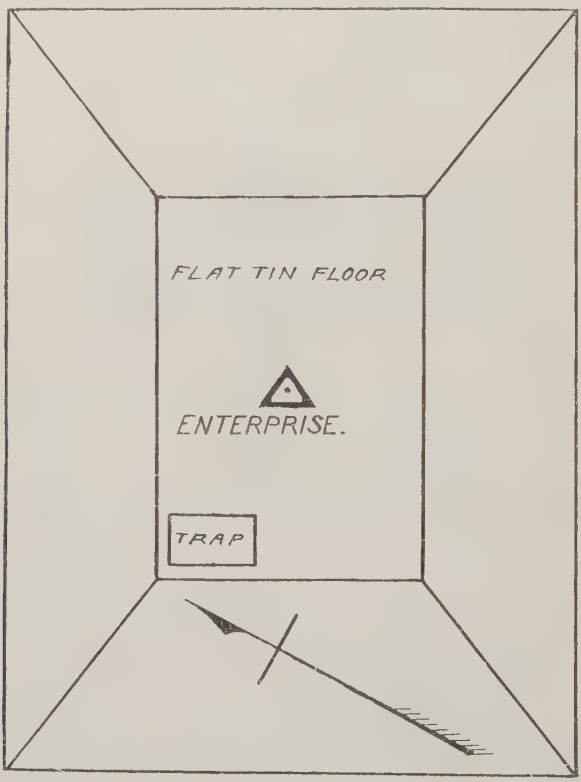


ENTERPRISE.

This station is the flagpole on the clubhouse of the Enterprise Fishing Club, Broad Channel, Borough of Queens, New York City, N. Y.

The building is two stories in height, surmounted by a red-roofed, rectangular cupola. A large weather-vane is attached to the pole.

Reached by L. I. R. R. to Broad Channel.

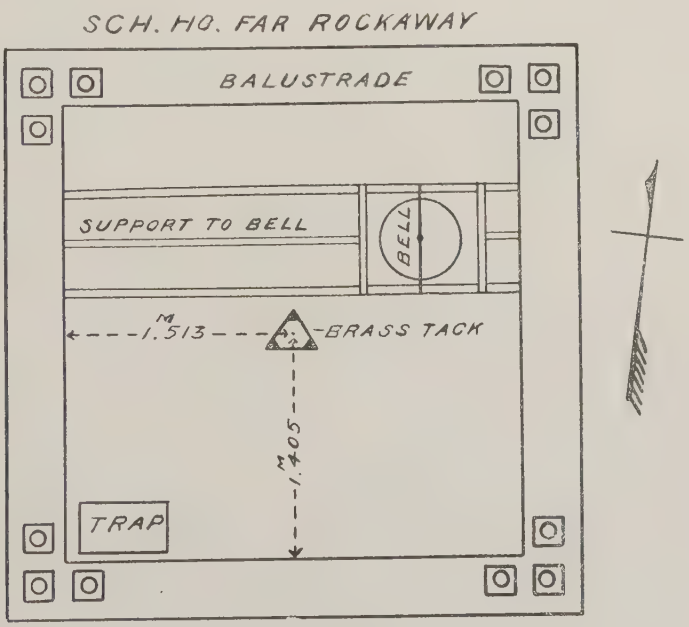


FAR ROCKAWAY SCHOOLHOUSE.

This station is the flagpole on the tower of Public School No. 39, on State street and Roanoke avenue, Far Rockaway, L. I.

It is reached by L. I. R. R. to Far Rockaway, either from Flatbush avenue, Brooklyn, or Long Island City.

The observations were taken from the bell platform just below the flagpole, but as Prospect Water Tower was situated behind a building at Far Rockaway, it was found necessary to build a tripod about 8 feet high to raise the theodolite so as to see Prospect Water Tower. The tower is very shaky for observation purposes, making all pointings very difficult.



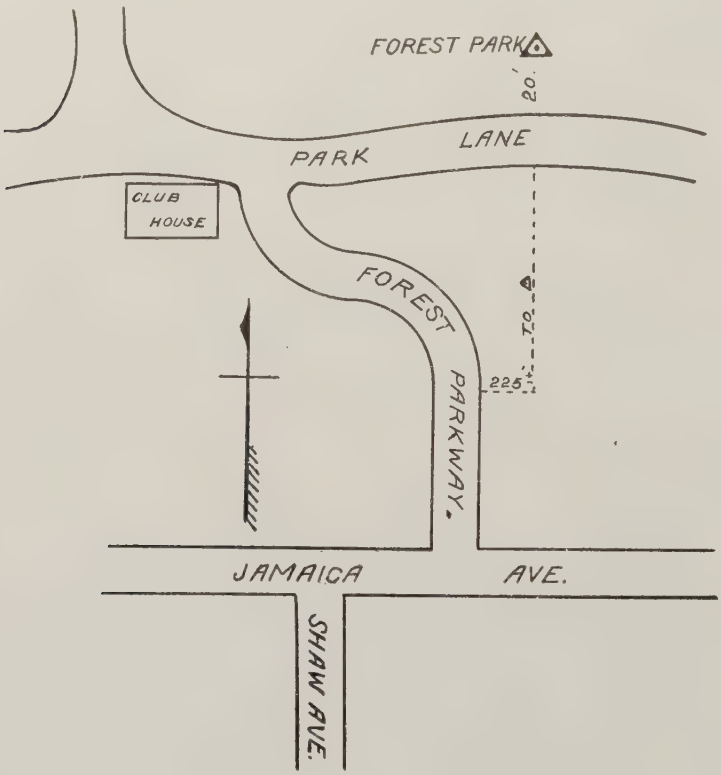
FOREST PARK.

This consists of an 84-foot tripod and scaffold in Forest Park, Borough of Queens, New York City, N. Y.

It is 20 feet north of Park lane and 225 feet ± east of the easterly line of Forest Parkway, as shown on sketch.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by train on L. I. R. R. to Union Course station, thence walking north to Forest Park.

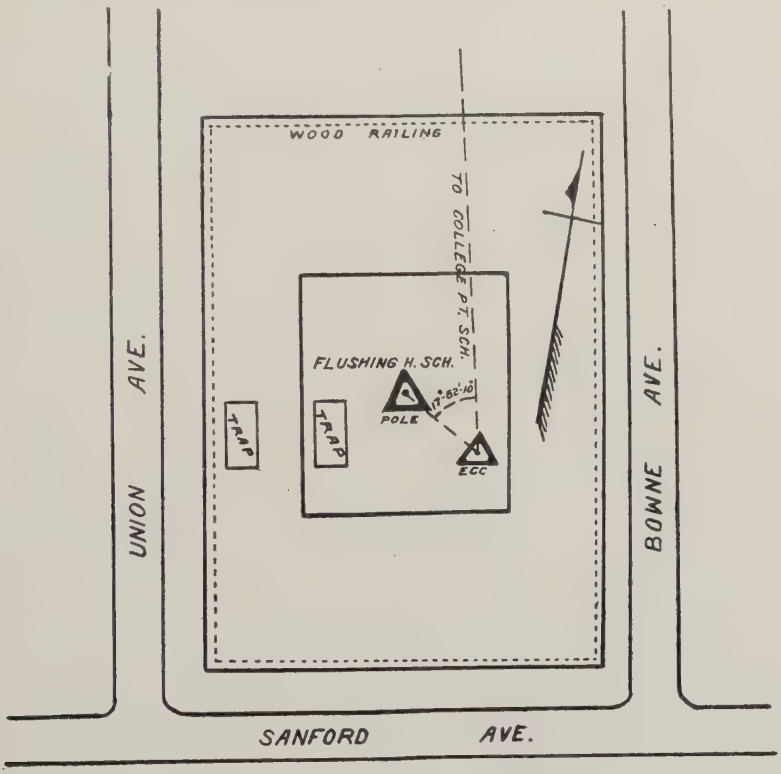


FLUSHING HIGH SCHOOL.

This is a four-story red brick building on the northwest corner of Sanford and Union avenue, Flushing, Borough of Queens, New York City, N. Y.

The center of the station is the flagpole on the roof. The eccentric station consists of a low and wide tripod built near the pole and spanning the low square cupola surrounding the pole. The eccentric station is marked by a brass tack on top of cupola.

The station is reached by L. I. R. R. from Long Island City to Main street, Flushing, then walking up Main street to Sanford avenue, thence left to Union avenue.

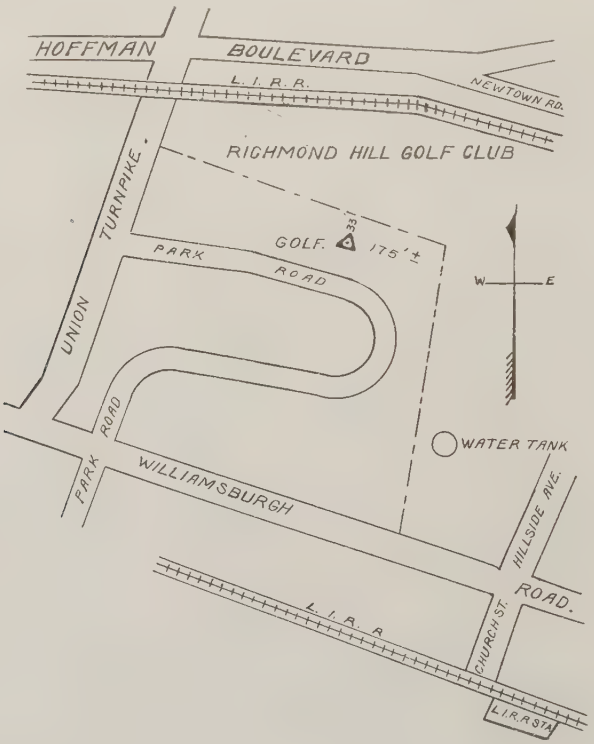


GOLF.

This station consists of a 52-foot tripod and scaffold near the extreme northeast corner of Forest Park. The station is in the park just south of a row of trees forming the northerly boundary line, as shown in sketch.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by L. I. R. R. from Long Island City to Richmond Hill, walking up Church street to Williamsburgh road, thence west on Williamsburgh road to the Park road, as shown on sketch, thence north and east to station.



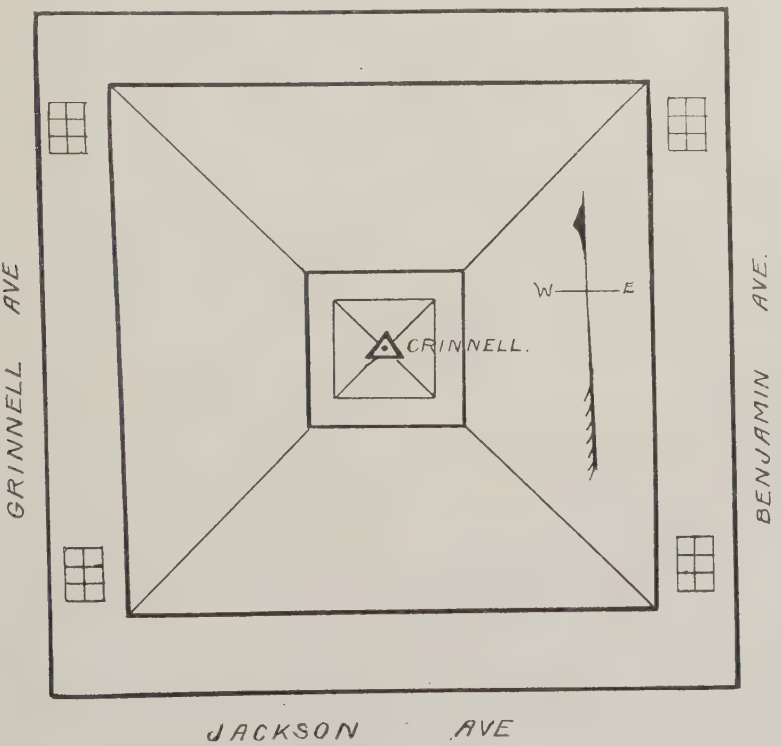
GRINNELL.

This station is a three-story frame building known as the Grinnell Mansion, but now used as an annex school by the Board of Education of New York City, N. Y.

It is situated 200 feet west of Jackson avenue, between Grinnell avenue and Benjamin avenue, Borough of Queens, New York City, N. Y.

The station consists of the center of the cupola on top of the building 10 feet above the roof. A tripod to support the instrument was built on the cupola and a scaffold for the observer was built up from the main roof. The cupola is very shaky in a wind.

Station is reached by trolley from Long Island City to Grinnell avenue.

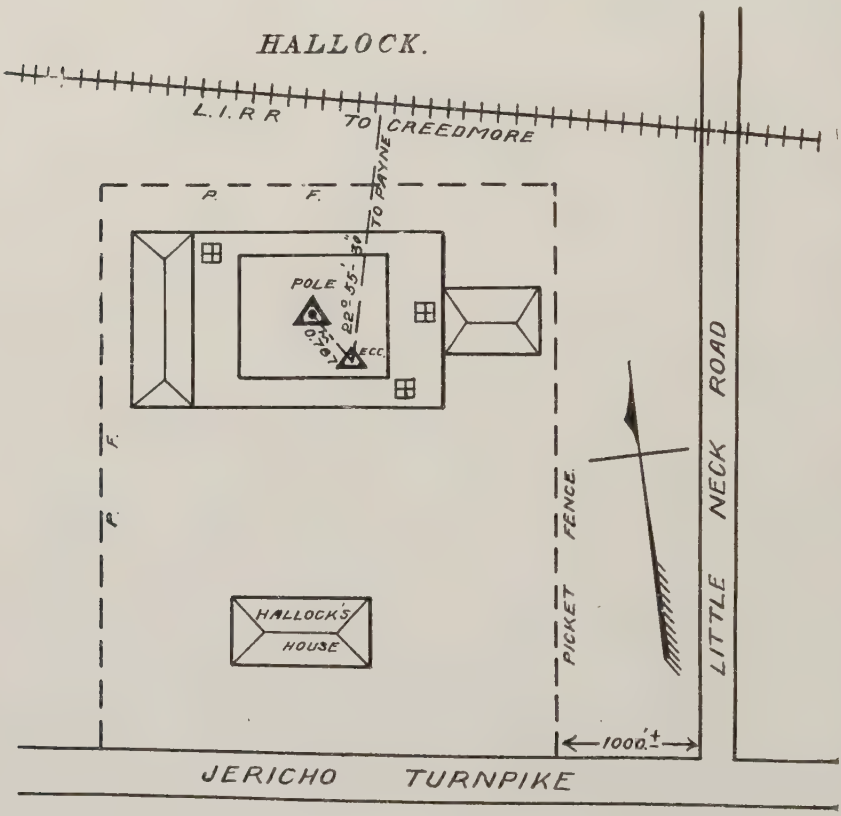


HALLOCK.

This station is the flagpole on the cupola of E. Hallock's seed store on the north side of the Jericho Turnpike, between Rocky Hill road and Little Neck road, near the Village of Queens, Borough of Queens, New York City, N. Y.

The cupola is square in plan with slightly inclined and gravel roof. It is very shaky and a platform was built for an observer to stand on.

Station is reached by L. I. R. R. from Flatbush avenue, Brooklyn, or from Long Island to Floral Park, thence north on Tulip avenue to Jericho Turnpike and station.



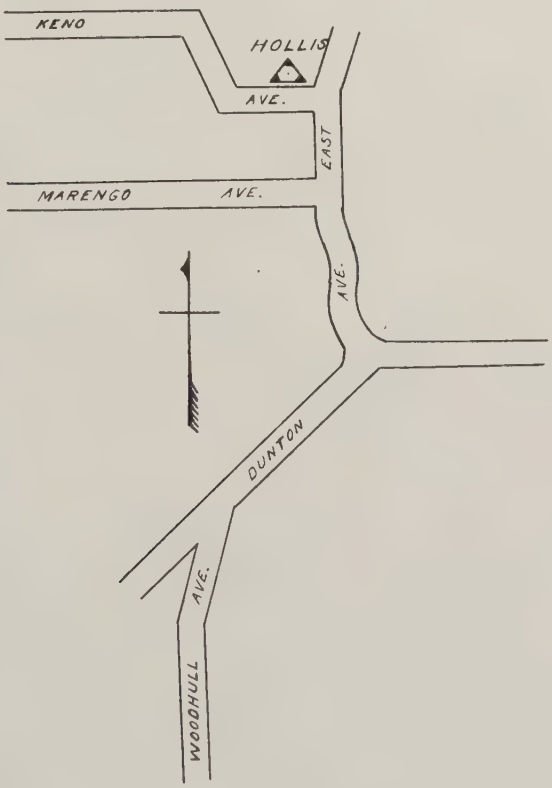
HOLLIS.

This station is at the corner of Dunton and Keno avenues, Holliswood, and about three miles northeast of Jamaica, Borough of Queens, New York City, N. Y.

It is reached by trolley to Jamaica, thence by trolley to Carpenter street, opposite Goetz's Hotel.

The high ridge north of trolley road is Holliswood, and a walk of about half a mile takes one to station. Here the land was bought by the City of New York and a tripod and scaffold 68 feet in height erected among the high trees to see Prospect Water Tower; Memorial Church; Jackson; Schoolhouse, College Point; Schoolhouse, Far Rockaway; Centennial Tower, etc.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.



HOPEDALE.

This station consists of a 30-foot tripod and scaffold on the land of Arthur Jesser, formerly the Van Dine estate, in the Village of Hopedale, Borough of Queens, New York City, N. Y. It is just north and west of the intersection of Hoffman Boulevard.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

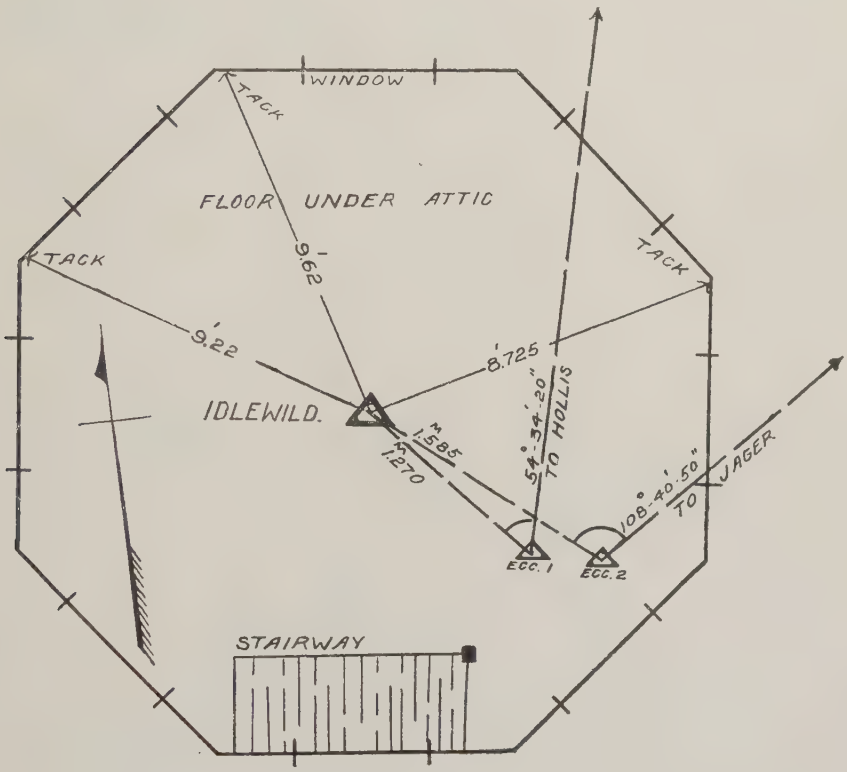
The station is reached by trolley from Brooklyn or Flushing, getting off at Corona avenue and Strong's Causeway, walking east on Corona avenue to Hoffman Boulevard and thence southeast to station.

IDLEWILD.

This station is the pole on the tank house of L. Eppig's amusement property at Idlewild, on the north shore of Jamaica Bay.

The building is of white, octagonal in shape, with a red conical roof. It is three stories high with eight windows on each floor. A point was dropped by a transit on the top floor and this was used for observations.

Reached by L. I. R. R. to Broad Channel, thence by boat to station.

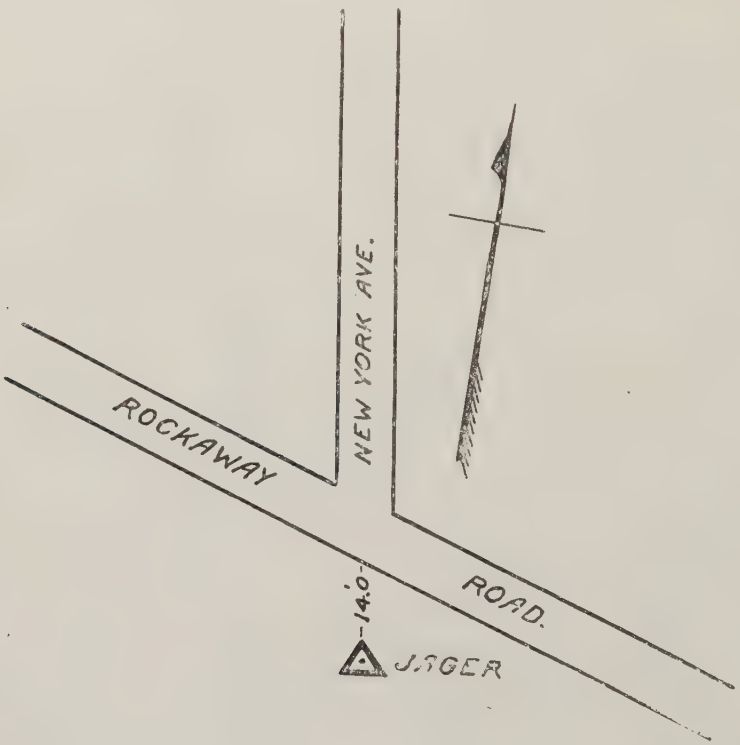


JAGER.

This station consists of a 68-foot tripod and scaffold on the farm of Mr. Jager, near the intersection of Rockaway road and New York avenue, Borough of Queens, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Station is reached by L. I. R. R. to Jamaica, thence by Far Rockaway trolley from Jamaica to Rockaway road to New York avenue.



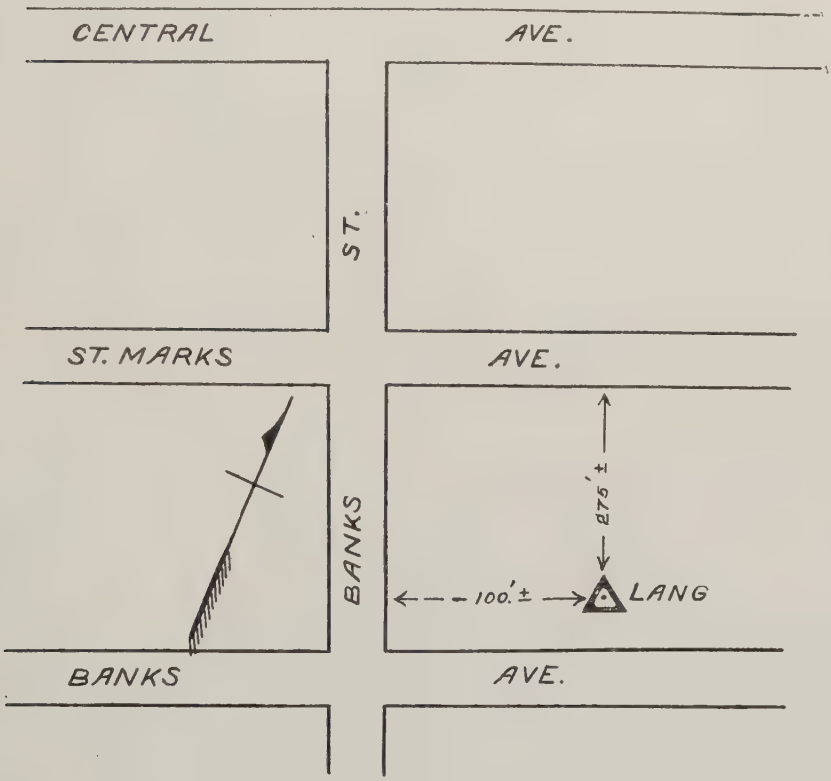
LANG.

This station consists of a 52-foot tripod and scaffold on the old Lang estate between Springfield and St. Albans, Borough of Queens, New York City, N. Y.

The station is about 300 feet east of the intersection of Banks street and St. Mark's avenue.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′ The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Reached by L. I. R. R. from Flatbush avenue, Brooklyn, or from Long Island City to Springfield, thence north on Springfield avenue to Lang estate, thence west to station.

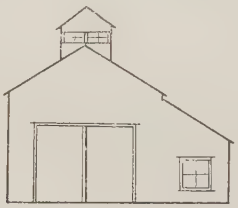


LIFE SAVING STATION, ROCKAWAY POINT.

Station Life Saving Station, Rockaway Point, is the apex of the square pyramidal roof on Rockaway Point life saving station, Rockaway Point, Borough of Queens, New York City, N. Y.

The building is of wood, painted a drab color. The roof is shingle. It is situated about one and three-quarter miles southwest of Rockaway Park railroad terminal and about 1,000 feet north of ocean shore, opposite Carmen's bungalow.

Reached by L. I. R. R. to Rockaway Park, thence by carriage to station.

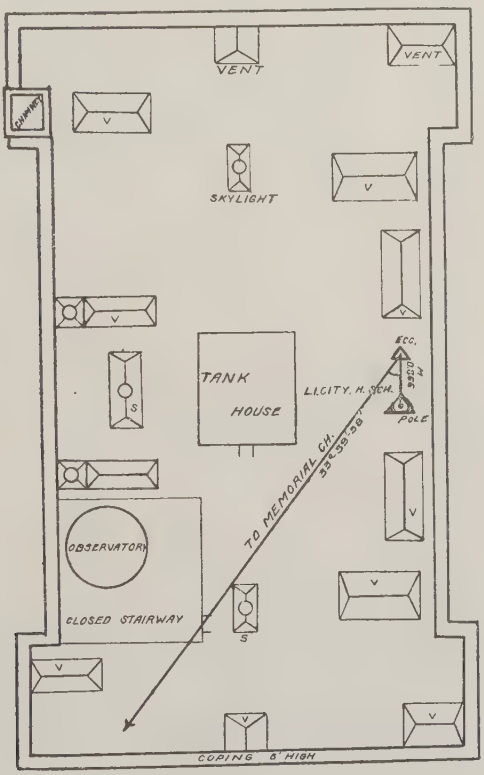


LONG ISLAND CITY HIGH SCHOOL.

This station is the flagpole on Bryant High School, situated on Academy avenue, between Wilbur avenue and Radde street, Long Island City, Borough of Queens, New York City, N. Y.

The building is rectangular in plan, of red brick with white trim. The roof is flat, tar and gravel, containing a number of ventilators and skylights. In the middle of the roof is a tank house 12 feet high, and on one corner is an observatory consisting of a 15-foot dome surmounting a square base 12 feet high. On account of these structures it was necessary to construct a 16-foot observing tripod and scaffold over the eccentric station.

Reached by Dutch Kills trolley from Thirty-fourth street and Ninety-second street ferries.



LUTHERAN CEMETERY CHURCH.

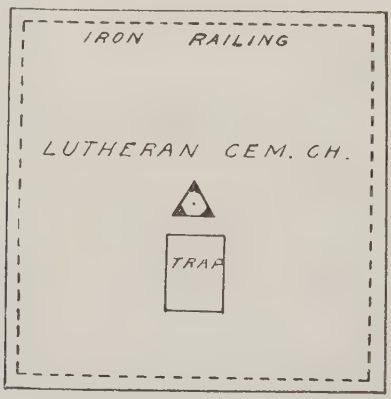
This station is the tower of Lutheran Cemetery Church and is situated near junction of Metropolitan avenue and Middle Village, L. I.

The tower is wholly of wood and square in plan, the upper portion of which is slightly tapered and has slate covering. Around edge of roof is an ornamental iron railing about 3 feet high. Access to roof is through a scuttle to one side of center of tower.

The station is at center of stump of flagpole (4 inches diameter) in center of roof of tower. This stump now extends from 3 feet above roof to about 8 feet below same, the whole being rigidly fastened.

For signal to observe upon a 4″ x 4″ piece of timber 12 feet long, painted in alternate bands (2 feet long) of black and white, was spliced to the top of stump, making the effective height of pole 15 feet, at the top of which was placed a white lozenge.

The church was destroyed by fire in 1906, making station useless.

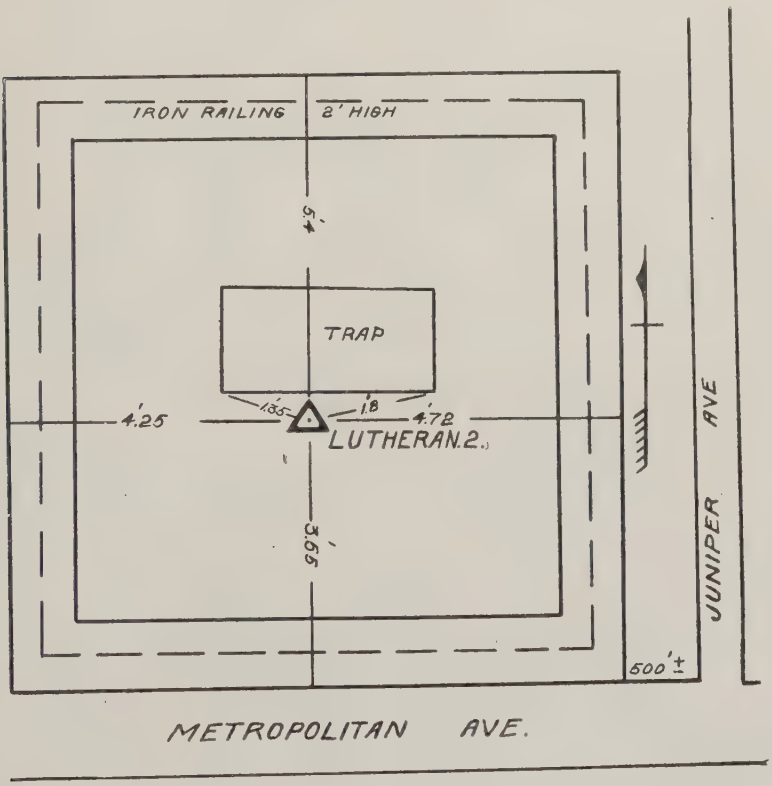


LUTHERAN 2.

This station is the top of a square tower about 60 feet high, containing the office of the Lutheran Cemetery Corporation, on the north side of Metropolitan avenue, 500 feet ± south of Juniper avenue, Borough of Queens, New York City, N. Y.

This station was selected to take the place of Lutheran Church, close by, which burned down. The point is marked by a 40d. nail in stump of the flagpole near center of tower. Under the roof of the tower is a large bell which rings violently when funerals pass in to the cemetery.

Station is reached by trolley from Brooklyn or Long Island City, getting off at office of cemetery.

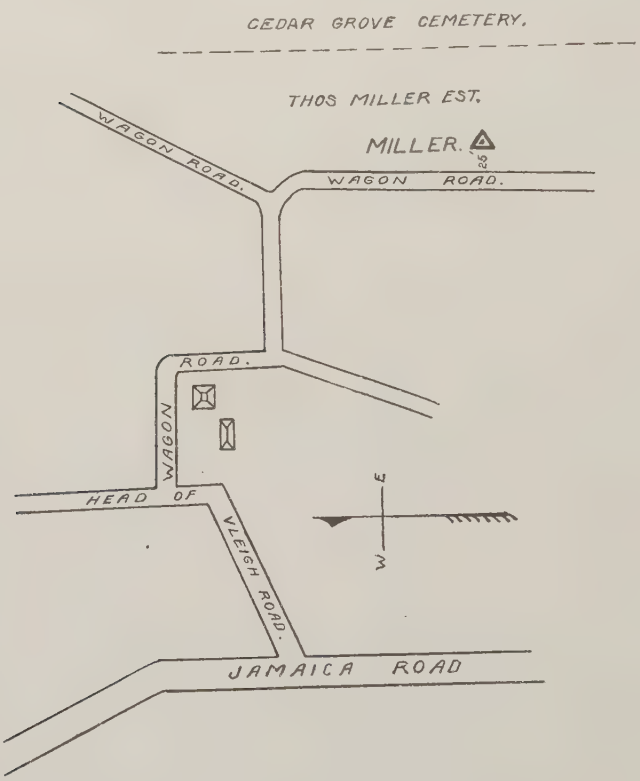


MILLER.

This station consists of an 84-foot tripod and scaffold on the farm of Thos. Miller, near Flushing, Borough of Queens, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by carriage from Flushing or Jamaica.



METROPOLITAN.

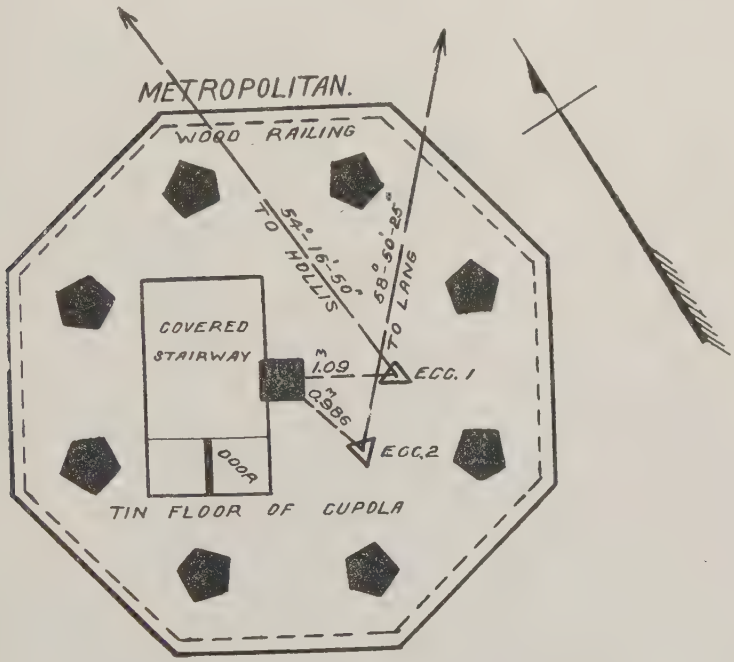
This station is the flagpole on the clubhouse of the Metropolitan Jockey Club, situated on Locust avenue, 1,000 feet ± east of New York avenue, Jamaica, Borough of Queens, City of New York, N. Y.

The clubhouse is surmounted by an open octagonal cupola where observations were taken.

The building is of wood as is the cupola, the roof of which is a natural wood color.

The pole is encased in a square column from top of cupola to floor.

Reached by Far Rockaway trolley from Jamaica to Locust avenue.

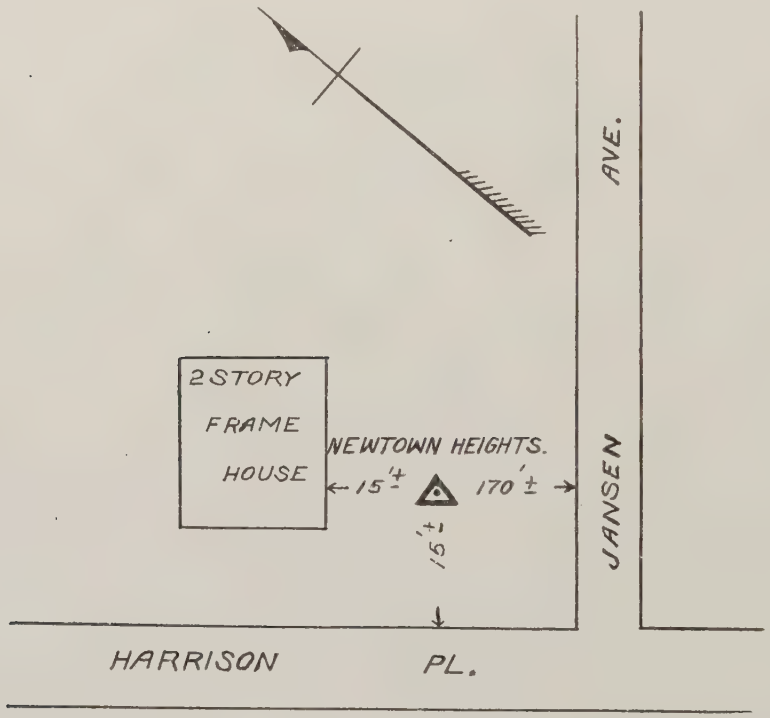


NEWTOWN HEIGHTS.

This station consists of a 52-foot tripod and scaffold on a vacant lot alongside of the house of Mr. Ernst Weber, 170 feet northwest of the intersection of Harrison place and Jackson avenue, Newtown Heights, Borough of Queens, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Station is reached by Brooklyn or Flushing trolley to Grand street and Prospect place, then walking southeast about one-third of a mile to Weber's house.



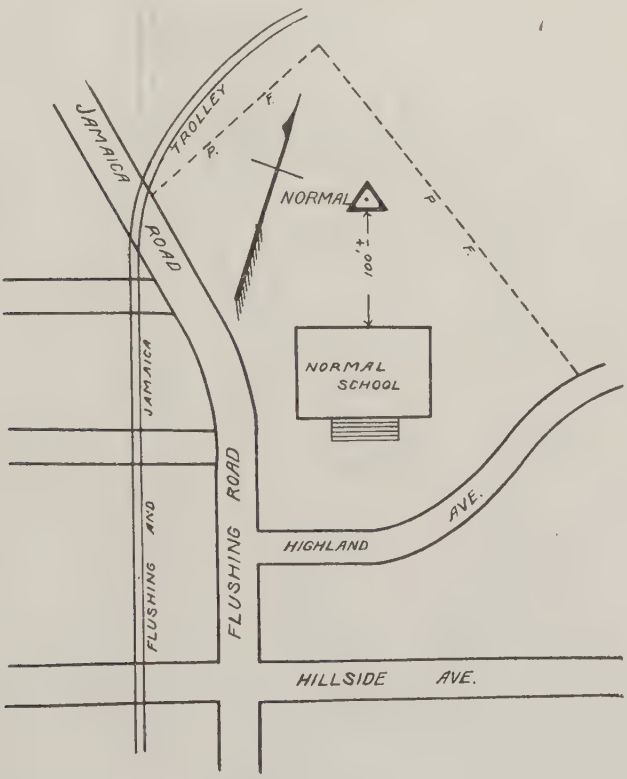
NORMAL.

This station consists of an 84-foot tripod and scaffold 100 feet ± north of the Jamaica Normal School, Jamaica, Borough of Queens, New York City, N. Y.

The station is situated on the school grounds.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Station is reached by L. I. R. R. from Long Island City, or from Flatbush avenue, Brooklyn, to Jamaica, thence walking north on Flushing avenue to Normal School.

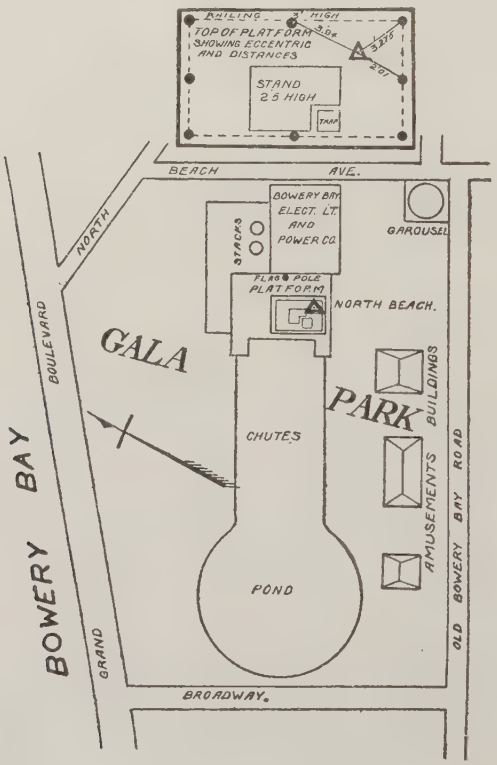


NORTH BEACH.

This station is a spike in the platform surmounting the chutes in Gala Park, North Beach, Borough of Queens, New York City, N. Y. These chutes are situated in the northeasterly corner of said park and are attached to the powerhouse of the Bowery Bay Electric Light and Power Co.

The platform is square in plan, of wood, and raised about 25 feet above the top of the chutes on wooden legs. The structure is painted white; the floor of platform is flat.

The station is reached by North Beach trolley from Astoria Ferry or Long Island City to North Beach; walk northwest along Grand Boulevard to Gala Park.

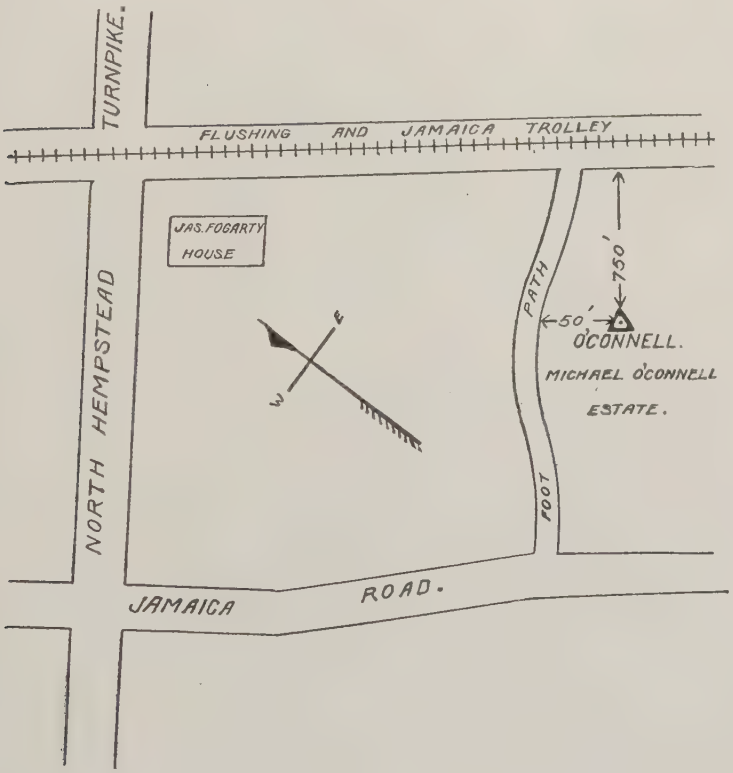


O'CONNELL.

This station consists of a 52-foot tripod and scaffold on the estate of Michael O'Connell, between Flushing and Jamaica, Borough of Queens, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by trolley from Jamaica or Flushing, getting off at footpath south of North Hempstead Turnpike.



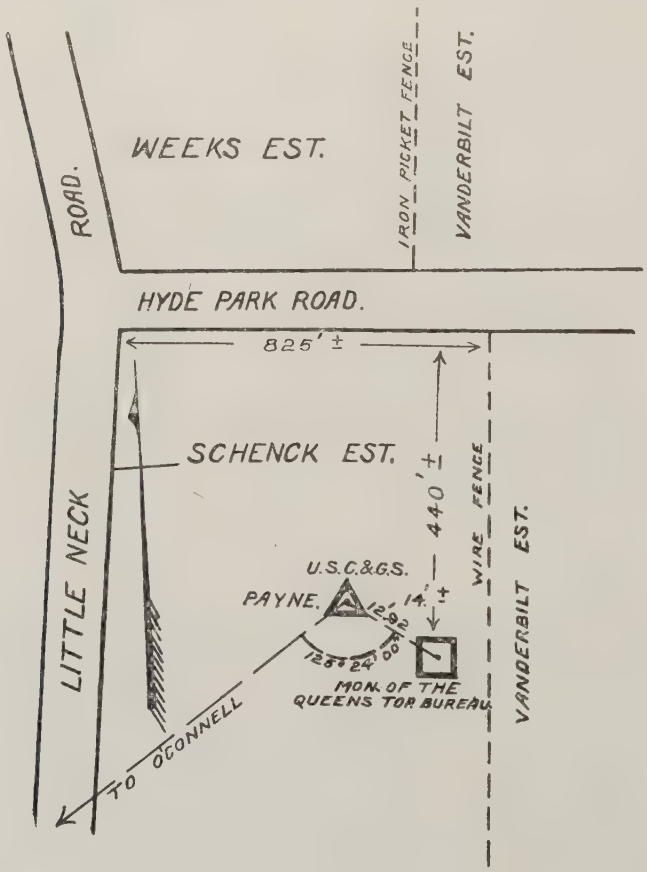
PAYNE.

This station is a 52-foot tripod and scaffold on the land of Mrs. Schenck, near the Town of Little Neck, L. I. It is just within the easterly boundary of New York City.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The monument to the southeast is the property of the Borough of Queens Topograpical Bureau.

The station is reached by train to Floral Park, and thence by carriage to Hyde Park road and station.

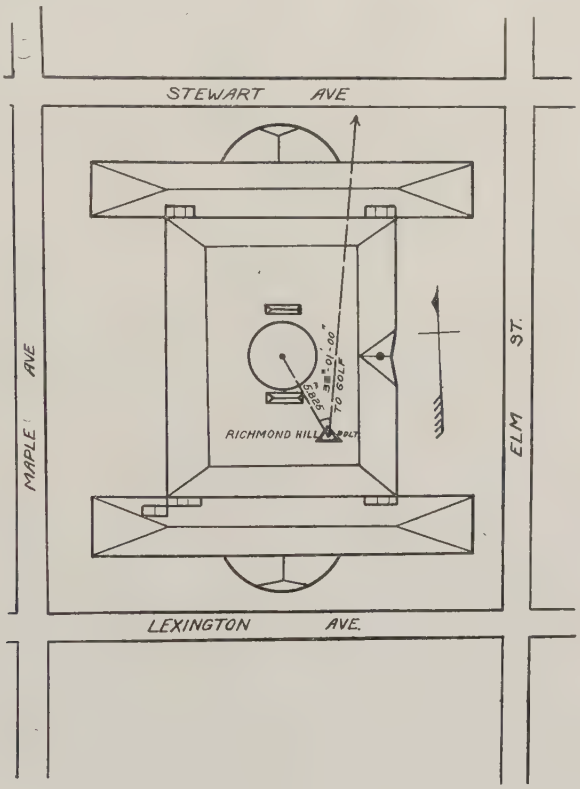


RICHMOND HILL HIGH SCHOOL.

This station consists of a point on the flat roof of the Richmond Hill High School, situated in the center of the block bounded by Maple street, Elm street, Stewart and Lexington avenues, Richmond Hill, Borough of Queens, New York City, New York.

An astronomical observatory and dome occupies the center of the roof and the triangulation station is 5.285 meters southeast of the center. The point is marked by a ½-inch iron bolt securely set in the roof and projecting 1½ inches.

Station is reached by L. I. R. R. from Flatbush avenue, Brooklyn, to Morris Park station, or by L. I. R. R. from Long Island City to Richmond Hill.

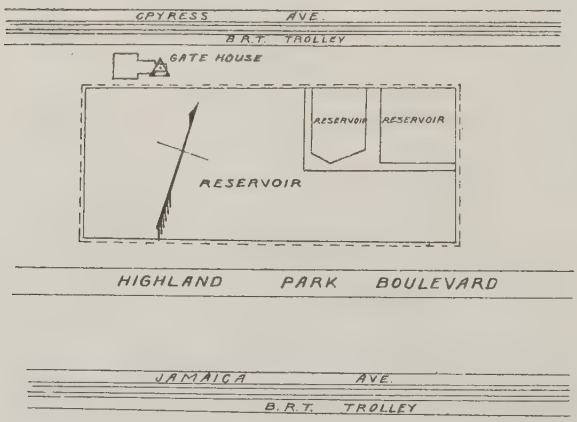


RIDGEWOOD GATEHOUSE.

Ridgewood Gatehouse is the vane rod on the gatehouse of Ridgewood reservoir, Highland Park Boulevard and Cleveland street, Borough of Queens, New York City, N. Y.

The building is situated on the northerly side of the reservoir and is of terra cotta brick with slate roof. The tower is square in plan with a pointed, concave roof.

Reached by Lexington avenue elevated to Cleveland street station; walk north to station.



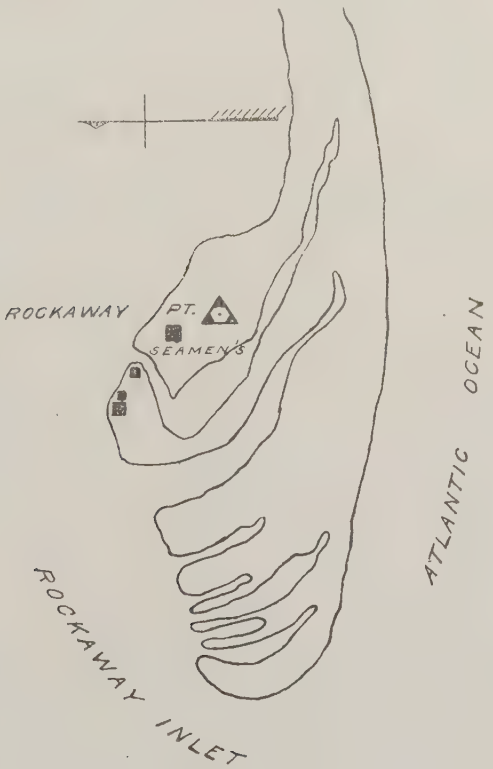
ROCKAWAY POINT.

This station is situated on Rockaway Point, Borough of Queens, New York City, N. Y.

The station is 565 feet ± to a tack driven in the southeast corner of Seaman's Old Hotel, two feet above ground. The angle at this point between Barren Island Schoolhouse to station is 110° 17′ 20″.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A cross cut on top of bolt marks the center.

Reached by Brighton Beach elevated train to Sheepshead Bay, thence by launch to Rockaway Point.

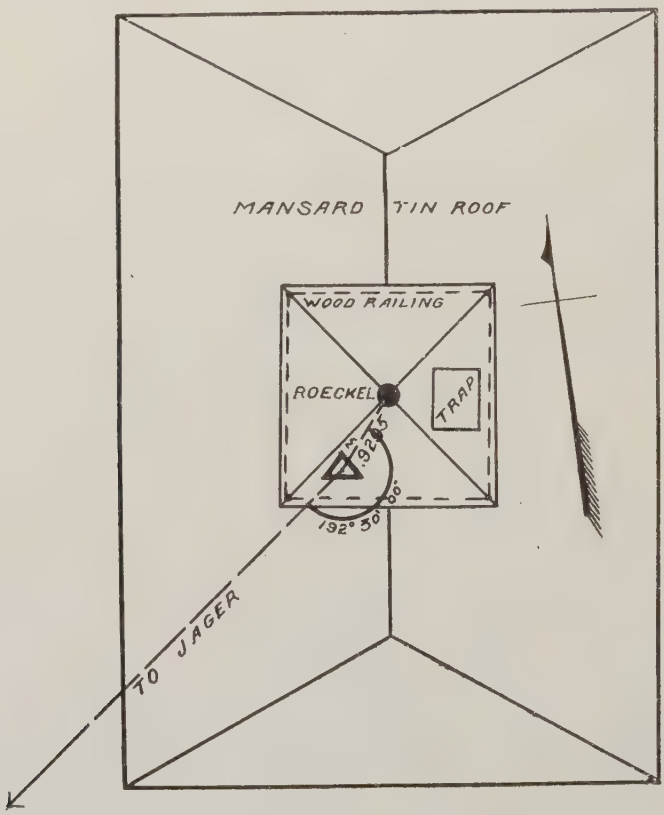


ROECKEL.

This station is the flagpole on the general store of George Roeckel, Merrick road and Ocean avenue, Foster's Meadow, Borough of Queens, New York City, N. Y.

The building is of wood, two stories high, with a small platform on the roof from which observations were made.

Reached by L. I. R. R. to Rosedale; walk north about one-half mile to station; or by City Line "L" to Grand avenue (terminal), thence by Freeport trolley to Rosedale.



SEASIDE HOTEL.

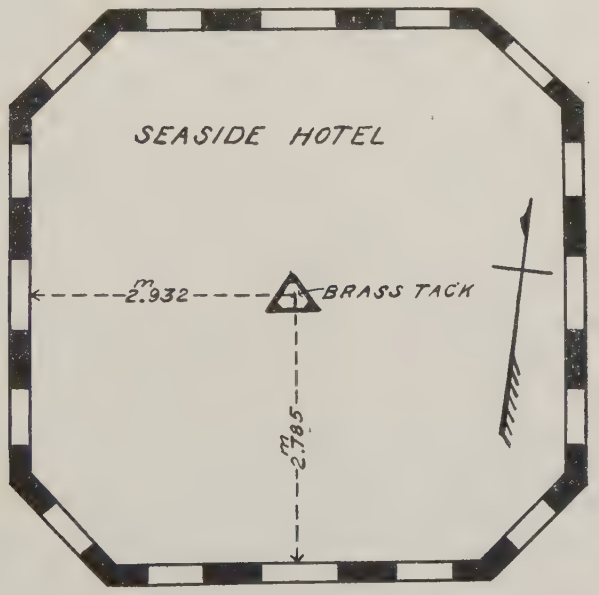
This station is the wooden flagpole on the large tower of Seaside Hotel, Rockaway Beach, Borough of Queens, New York City, N. Y.

It is reached by Rockaway Beach train for Seaside on the L. I. R. R. from either the Flatbush avenue station, Brooklyn, or Long Island City.

The observations were taken from a room at the top of the tower at Seaside Hotel. The base of the pole projects through the ceiling of the room, the center so obtained being transferred to the floor.

In 1908 it was suspected by Mr. Koop that the base of the pole was not exactly under the part of the pole above the roof which was observed upon from other stations.

Mr. Koop, in July, 1908, plumbed with transit the part of the pole above the roof to floor and it was marked by a brass tack in floor. This new station is 0.0815 meter from the old station of 1904 and at an angle of 97 degrees from Centennial Tower.

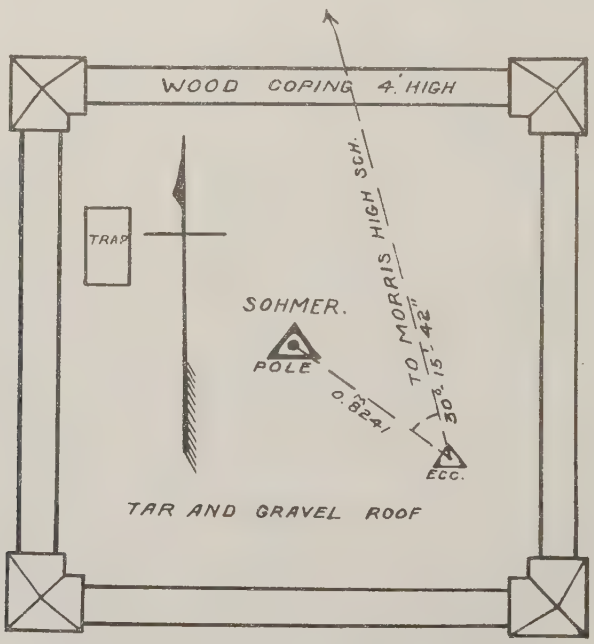


SOHMER.

This station is the flagpole on the clock tower of the Sohmer Piano Factory, Jamaica avenue and Boulevard, Astoria, Borough of Queens, New York City, N. Y.

The building is of red brick, "L" shaped, six stories high, with flat tar and gravel roof. The clock tower is located at the angle point of the "L" and is wooden, square in plan, converging toward the top. The floor is flat, of tar and gravel. A 4-foot wooden coping surmounts this roof.

The station is reached by Vernon avenue and Ninety-second street trolley from Long Island City or Ninety-second street ferries.



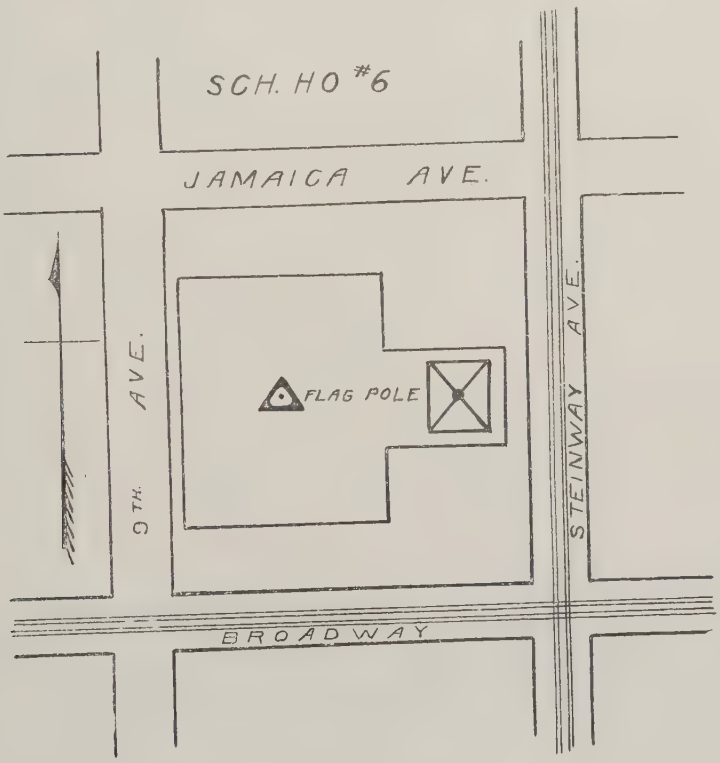
SCHOOLHOUSE NO. 6.

Station Schoolhouse No. 6 is the flagpole on the main building of Public School No. 6, Steinway avenue, near Broadway, Steinway, Borough of Queens, New York City, N. Y.

The building is of red brick, three stories high, with white trim. The main building has a flat tar and gravel roof. The pole is approximately in the center.

An extension, neither so wide nor so high as the main building, faces to the east on Steinway avenue. It has a mansard roof and is surmounted by a short square tower with a pyramidal roof. This tower also contains a pole.

Reached by Steinway car from Long Island City which passes school.

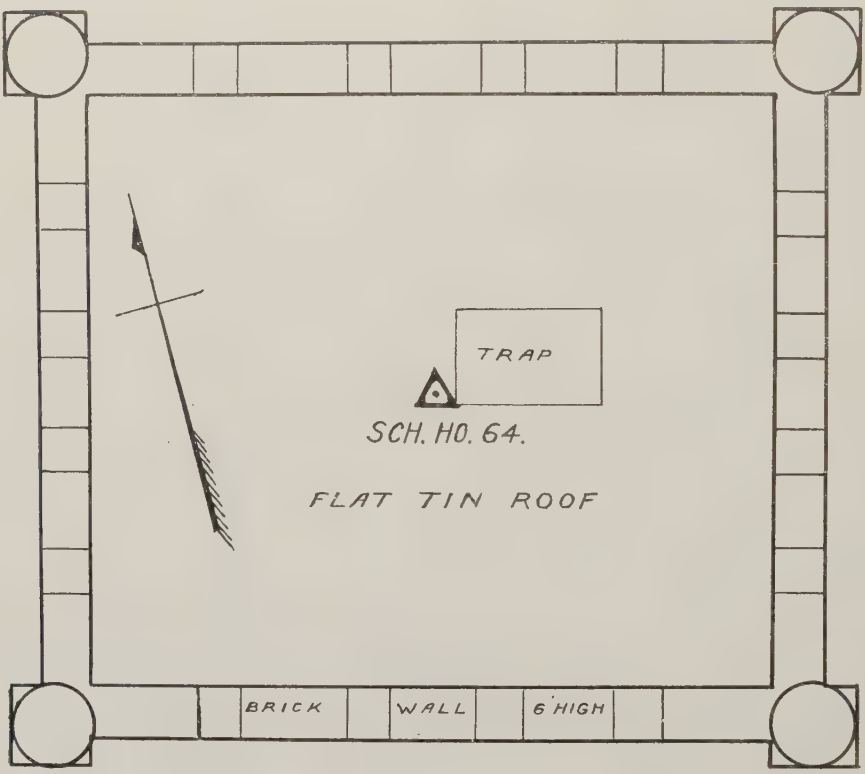


SCHOOLHOUSE NO. 64.

This station is a brass nail in the floor of the tower of Public School No. 64, Spruce street and Broadway, Woodhaven, Borough of Queens, New York City, N. Y.

The building is of red brick, two and half stories high. The tower is square in plan, of brick, two stories high.

Reached by City Line "L" to City Line, thence by Freeport trolley to school, or by L. I. R. R. from Flatbush avenue station to its Union Course station.



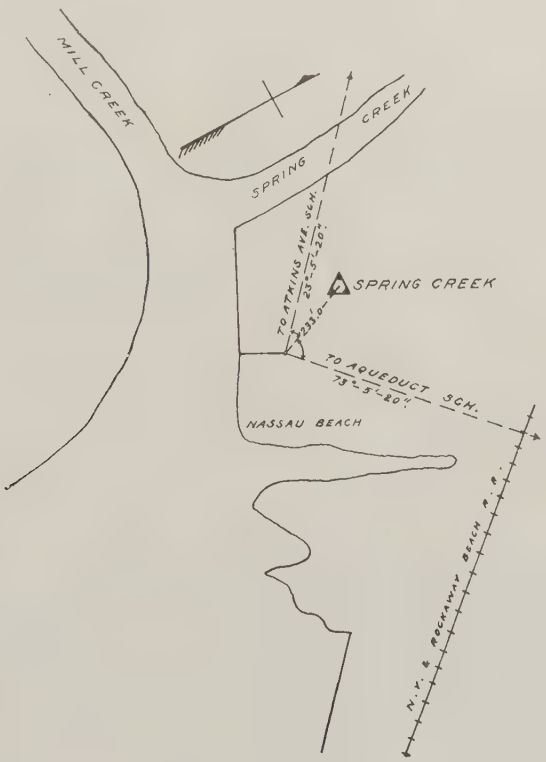
SPRING CREEK.

This station is situated on Nassau Beach at the mouth of Mill Creek, Borough of Queens, New York City, N. Y.

The station is referenced to large wire nail driven in pile at northeastern extremity of bulkhead, the distance being 233 feet. Reference angle taken at this point between Atkins Avenue Schoolhouse and station is 23° 5′ 20″, and between station and Aqueduct Schoolhouse is 73° 5′ 20″.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 3′ set in concrete 3′ x 3′ x 4′. A small hole drilled in top of bolt marks the center of station.

Reached by City Line elevated train to Crescent avenue, thence by carriage to Mill Creek, and by rowboat to Nassau Beach.



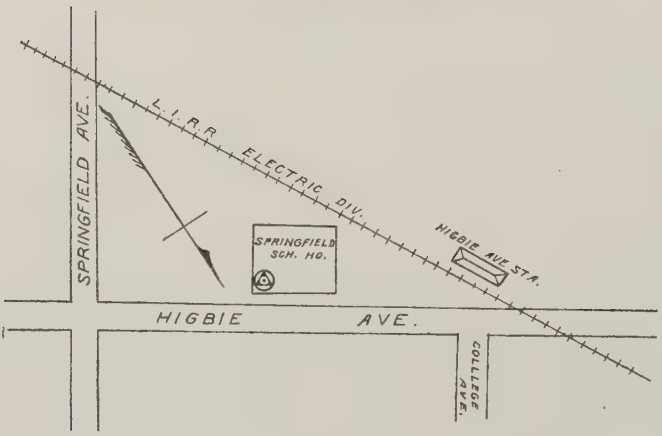
SPRINGFIELD SCHOOL.

Station Springfield School is a short pole about two feet high on the tower of Public School No. 37, Springfield, Borough of Queens, New York City, N. Y.

The building is painted drab, with red roof. It is built of wood, two and one-half stories high.

The tower is pyramidal in shape and rises about fifteen feet above the roof.

Reached by L. I. R. R., electric division, to Higbie avenue station, or by L. I. R. R., Montauk division, to Springfield station.

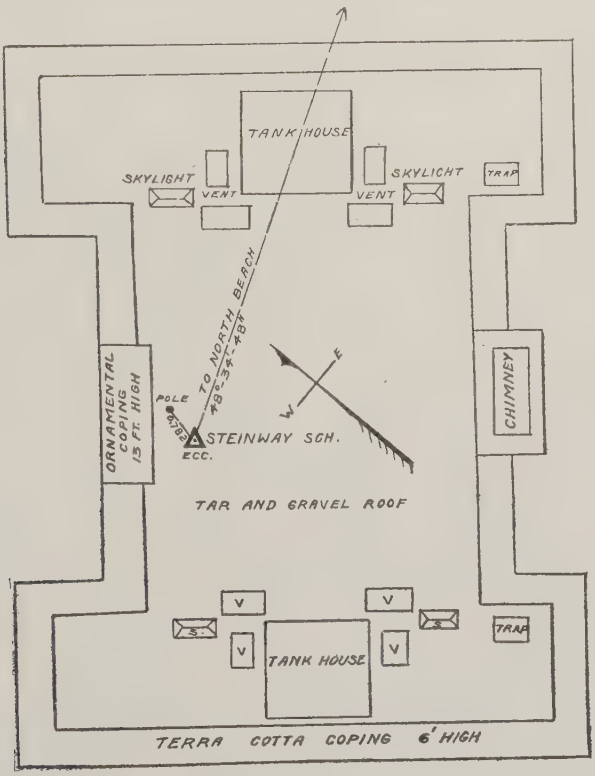


STEINWAY SCHOOL.

This station is the flagpole on Public School No. 84, situated on the east side of Albert avenue, between Ditmars and Potter avenues, Steinway, Borough of Queens, New York City, N. Y.

The building has three stories, red brick with terra cotta trim, flat, tar and gravel roof surmounted by a terra cotta coping. In order to see over this coping and the various tanks, etc., on the roof it was necessary to build a tripod and scaffold 13 feet high near the pole.

The station is reached by Steinway car from Ninety-second street or Thirty-fourth street ferries.

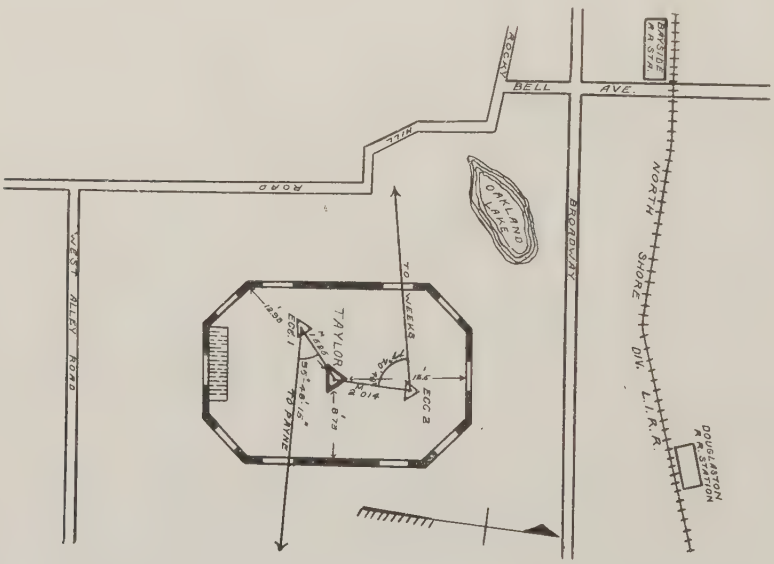


TAYLOR.

This station is the cupola of the house of John Taylor, near Bayside, Borough of Queens, New York City, N. Y.

Two eccentrics were established and all lines were obtained through windows at the sides of the room. The apex of the cupola is marked on the floor below by a brass screw and is referenced by measurements to the sides of the room.

Station is reached by L. I. R. R. from Thirty-fourth street, New York, to Bayside, thence by carriage to Taylor house.

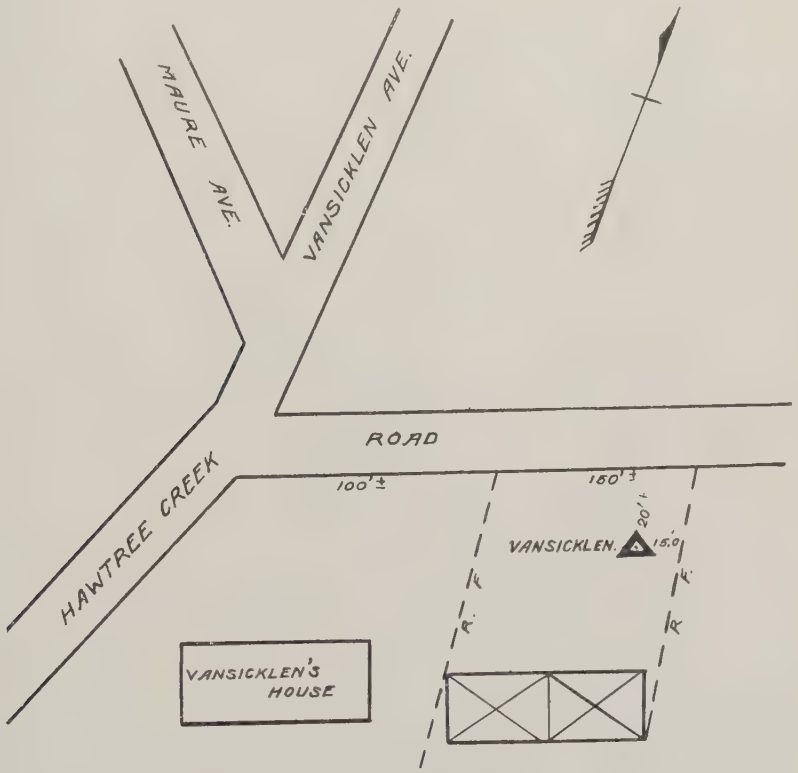


VAN SICKLEN.

This station consists of a 68-foot tripod and scaffold on the Van Sicklen farm, on the south side of Hawtree Creek road, just southeast of Richmond Hill, Borough of Queens, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite block 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

Station is reached by Brooklyn "L" to City Line, and then by Liberty avenue trolley to Van Sicklen avenue; then walk one-half mile southerly to Van Sicklen farm and station.

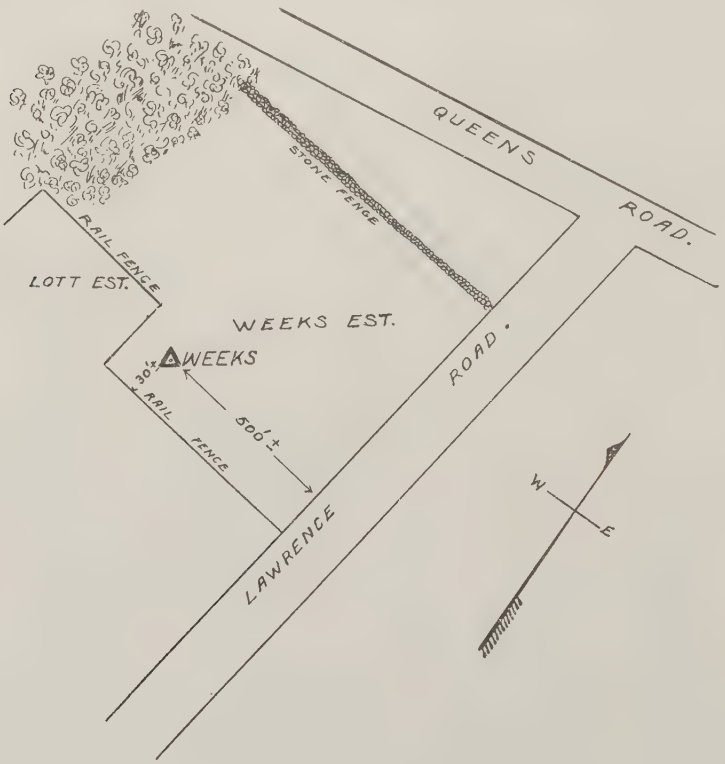


WEEKS.

This station consists of an 84-foot tripod and scaffold on the farm of the Weeks estate, near the intersection of Queens road and Lawrence road, Borough of Queens, New York City, N. Y.

The station is marked by the regular U. S. C. & G. S. brass marking bolt set in a granite post 6″ x 6″ x 24″ set in concrete 3′ x 3′ x 4′. The exact point is a small hole 1/100 foot in diameter drilled in top of bolt.

The station is reached by trolley or carriage from Flushing or Jamaica.

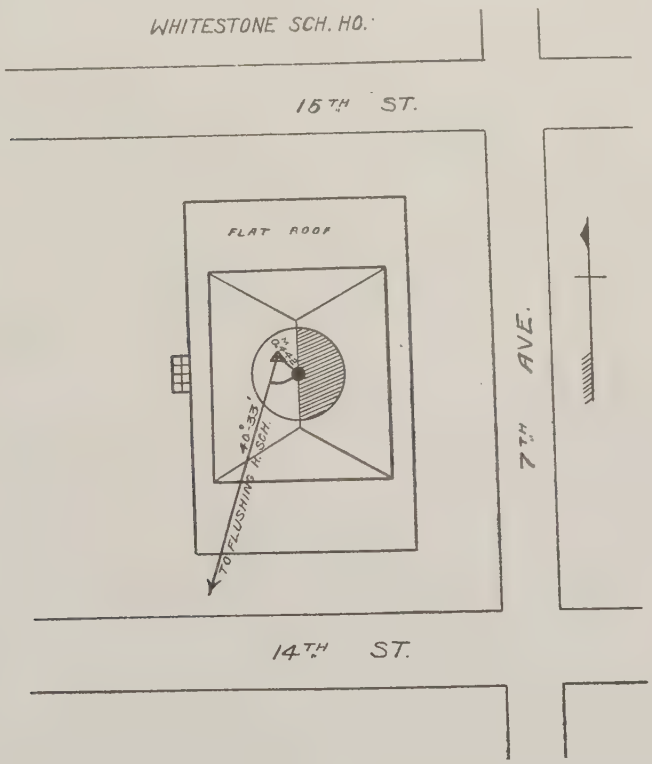


WHITESTONE SCHOOLHOUSE.

This station is the flagpole in the cupola of Schoolhouse No. 79, situated at Whitestone, Borough of Queens, New York City, N. Y.

The schoolhouse is a three-story red and white brick structure with mansard roof. The cupola is a short upright cylinder, one-half of which is built up as shown in sketch, leaving only a small space to work in. A small scaffold was built in the cupola on which to rest the instrument. The chimney shown in sketch is level with cupola and emits heat all day.

Station is reached by L. I. R. R. from Long Island City, New York, getting off at Whitestone, L. I.



Borough of Manhattan.

State of New Jersey.

Nassau County.

GEOGRAPHICAL

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
1	Highbridge	40 50 33.193	$1023^{m}.8$	73 55 58.856	$1378^{m}.8$
			$3358^{ft}.9$		$4523^{ft}.6$
2	Madison square	40 44 33.749	$1041^{m}.0$	73 59 11.174	$262^{m}.2$
			$3415^{ft}.3$		$860^{ft}.2$
3	Memorial church.....	40 46 57.559	$1775^{m}.4$	73 57 25.659	$601^{m}.7$
			$5824^{ft}.8$		$1974^{ft}.1$
4	Metropolitan Life building.....	40 44 28.589	$881^{m}.9$	73 59 15.902	$373^{m}.1$
			$2893^{ft}.4$		$1224^{ft}.1$

MANHATTAN.

POSITIONS.

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
283 35 36.72	103 40 07.62	Jackson	9989^{m}.13	3.9995275
			32772^{ft}.67	
310 51 23.92	130 54 47.50	College Point schoolhouse	9654^{m}.69	3.9847383
			31675^{ft}.48	
17 00 52.48	196 59 55.74	Memorial church	6955^{m}.79	3.8423467
			22820^{ft}.80	
27 46 39.65	207 45 48.69	Park Row building	3933^{m}.78	3.5948106
			12906^{ft}.08	
75 46 54.95	255 43 43.63	Bergen Dutch Reformed church	7098^{m}.13	3.8511442
			23287^{ft}.78	
139 33 40.14	319 32 27.74	Highwood 2	4009^{m}.92	3.6031352
			13155^{ft}.88	
209 08 51.38	29 10 00.27	Memorial church	5079^{m}.69	3.7058371
			16635^{ft}.62	
348 32 44.49	168 33 28.40	Prospect water tower	7963^{m}.41	3.9010992
			26126^{ft}.62	
4 11 24.15	184 10 59.24	Prospect water tower	12273^{m}.75	4.0889773
			40268^{ft}.13	
28 34 07.91	208 32 08.06	Park Row building	9012^{m}.84	3.9548617
			29569^{ft}.63	
276 14 46.99	96 23 28.42	Hollis	18866^{m}.28	4.2756862
			61897^{ft}.12	
298 16 14.15	118 24 52.62	Jager	21211^{m}.25	4.3265662
			69590^{ft}.58	
307 03 46.16	127 13 03.50	Far Rockaway schoolhouse	25196^{m}.24	4.4013358
			82664^{ft}.66	
321 30 14.87	141 36 37.57	Seaside Hotel	22190^{m}.05	4.3461583
			72801^{ft}.85	

BOROUGH OF

GEOGRAPHICAL

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
5	Park Row building....	40 42 40.910	$1261^{m}.9$	74 00 29.276	$687^{m}.2$
			$4140^{ft}.1$		$2254^{ft}.6$
6	Singer building.....	40 42 34.526	$1065^{m}.0$	74 00 39.602	$929^{m}.6$
			$3494^{ft}.1$		$3049^{ft}.9$
7	St. Patrick's cathedral, north spire....	40 45 31.790	$980^{m}.6$	73 58 37.261	$874^{m}.0$
			$3217^{ft}.2$		$2867^{ft}.4$

MANHATTAN.

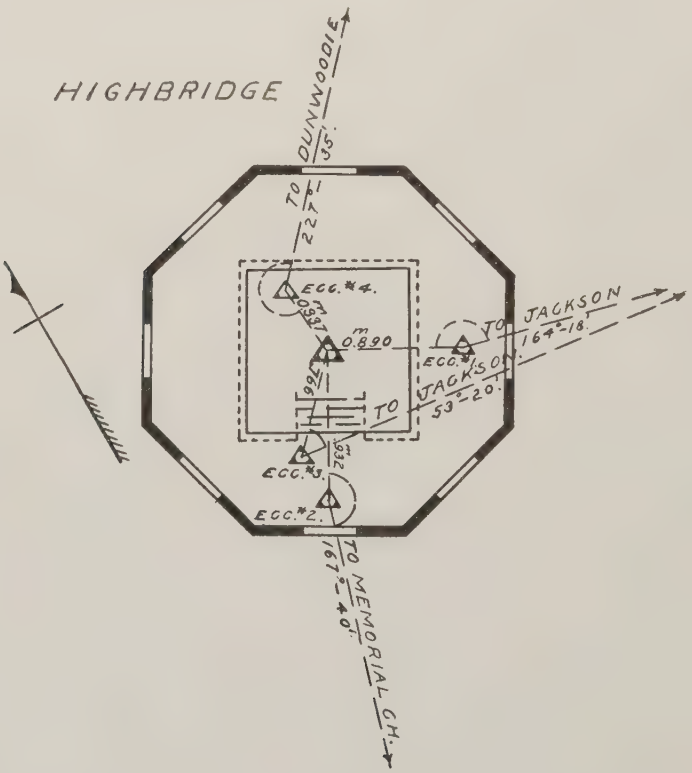
POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
321 41 21.56	141 42 56.38	Prospect water tower...	5510^{m}.02	3.7411533
			18077^{ft}.46	
19 01 23.41	198 59 29.94	Ft. Tompkins 2.....	12561^{m}.93	4.0990564
			41213^{ft}.60	
37 00 33.26	216 56 19.99	Bogart.....	15183^{m}.82	4.1813812
			49815^{ft}.61	
209 15 57.29	29 18 03.88	Memorial church.....	9302^{m}.39	3.9685943
			30519^{ft}.59	
265 56 21.01	86 05 56.87	Hollis.....	20770^{m}.78	4.3174527
			68145^{ft}.47	
287 31 54.79	107 41 27.64	Jager.....	21653^{m}.47	4.3355275
			71041^{ft}.43	
297 50 50.73	118 01 02.42	Far Rockaway school-house.....	24964^{m}.87	4.3973293
			81905^{ft}.58	
311 15 40.01	131 22 57.10	Seaside Hotel.....	20993^{m}.14	4.3220774
			68874^{ft}.99	
26 30 48.20	206 29 35.11	Park Row building.....	5890^{m}.01	3.7701185
			19324^{ft}.24	
65 17 12.31	245 13 38.83	Bergen Dutch Reformed church.....	8450^{m}.54	3.9268842
			27724^{f}.81	
110 22 57.15	290 21 22.59	Highwood 2.....	3623^{m}.18	3.5590893
			11887^{ft}.05	
212 23 49.58	32 24 36.34	Memorial church	3133^{m}.58	3.4960406
			10280^{ft}.75	
254 50 02.47	74 55 09.32	College Point school-house.....	11413^{m}.96	4.0574363
			37447^{ft}.30	
355 19 24.59	175 19 46.39	Prospect water tower...	9627^{m}.35	3.9835066
			31585^{ft}.73	

HIGHBRIDGE.

Station Highbridge Tower is the standpipe for the Highbridge reservoir on One Hundred and Seventy-fifth street, Manhattan Borough, just east of Amsterdam avenue.

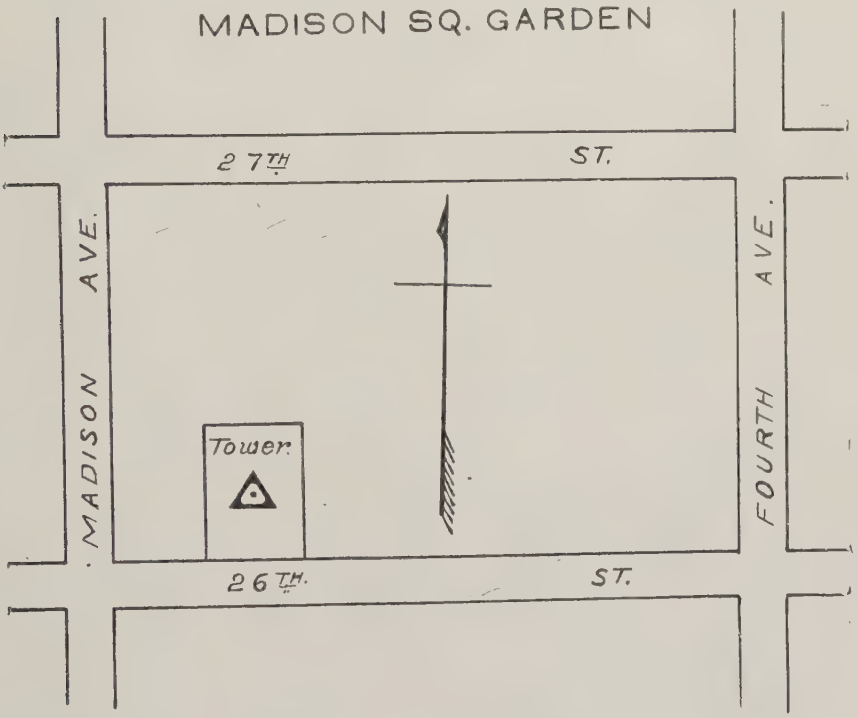
The tower above the tank is of wood with a large conical top, with windows two feet wide at the sides. It is octagonal in plan and has one window in each side of octagon. The floor of tower is of wood and quite rotten in spots. A wooden ladder enters through a hole 3′.5 x 3′.5 in floor, and this hole is surrounded on three sides by an iron fence 2.5 feet high, which is an extension of the iron handrail of the ladder.



MADISON SQUARE GARDEN.

This station is the top of the tower of the Madison Square Garden building, near the northeast corner of Madison avenue and Twenty-sixth street, Borough of Manhattan, New York City, N. Y.

The station is a tertiary one and was not occupied. The part of the tower sighted on is the small pedestal on which Diana stands.

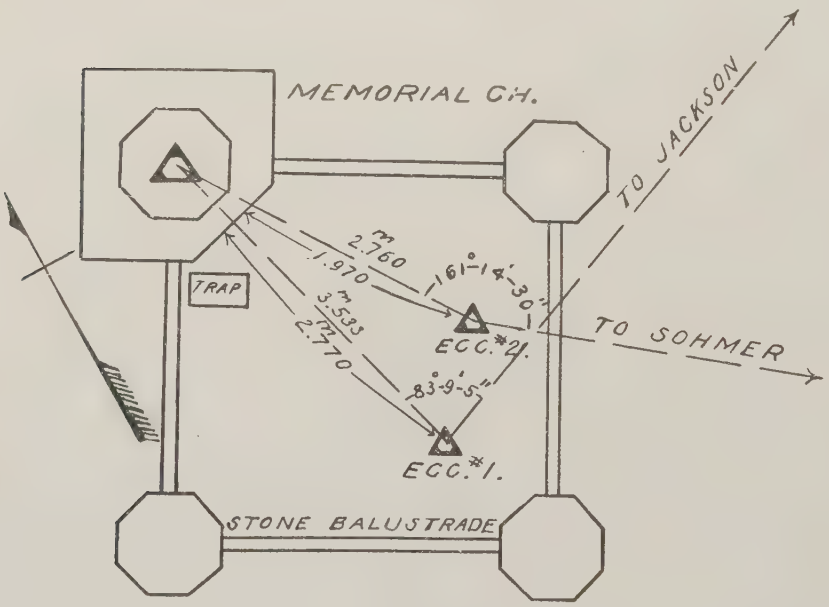


MEMORIAL CHURCH.

This station is the northwest minaret on the tower of the Church of the Beloved Disciple, on the north side of Eighty-ninth street, between Park and Madison avenues, New York City, N. Y.

The minaret chosen is the largest one of four. The roof of tower is flat with a tar-paper covering. Access to it is by means of scuttle in northwest corner.

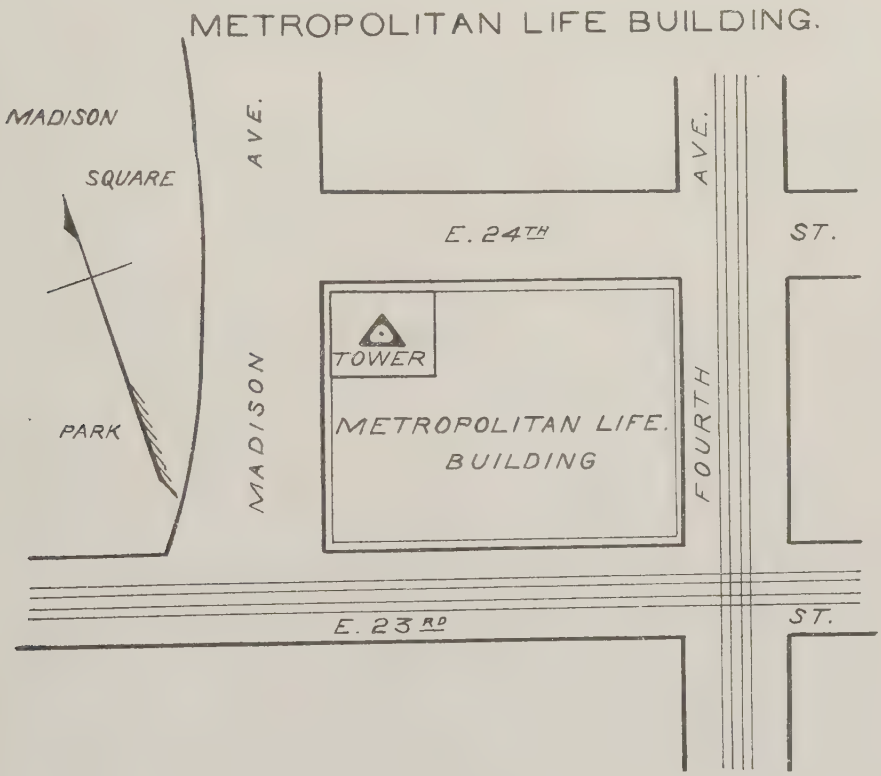
The tower is square in plan, of brown stone.



METROPOLITAN LIFE BUILDING.

This station is the flagpole on top of the tower of the Metropolitan Life Building, southeast corner of Madison avenue and Twenty-fourth street, Borough of Manhattan, New York City, N. Y.

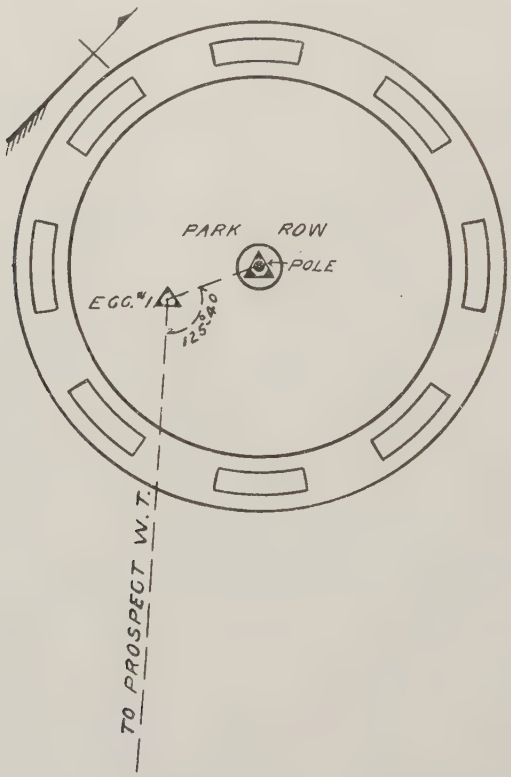
The station is a tertiary one and was not occupied.



PARK ROW.

This station is the flagpole on the north tower of the Park Row building at 13-21 Park Row, New York City.

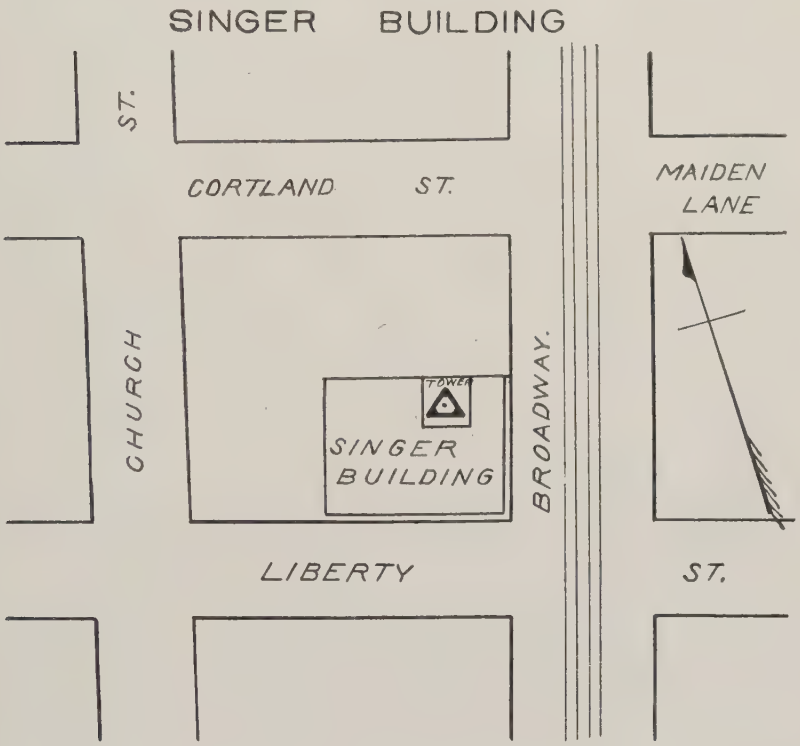
The observing platform is a copper-sheathed floor of said tower and is under a dome-shaped roof, which is supported by eight rectangular supports. The tower is reached by elevator to twenty-sixth floor and then by smaller elevator in the Robbins Belt Conveying Co., and then up a couple of flights of stairs through a trap door to floor of tower. The flagpole reaches down to observing platform and its center is taken as the station.



SINGER BUILDING.

This station is the flagpole on top of the tower of the Singer building, northwest corner of Broadway and Liberty street, Borough of Manhattan, New York City, N. Y.

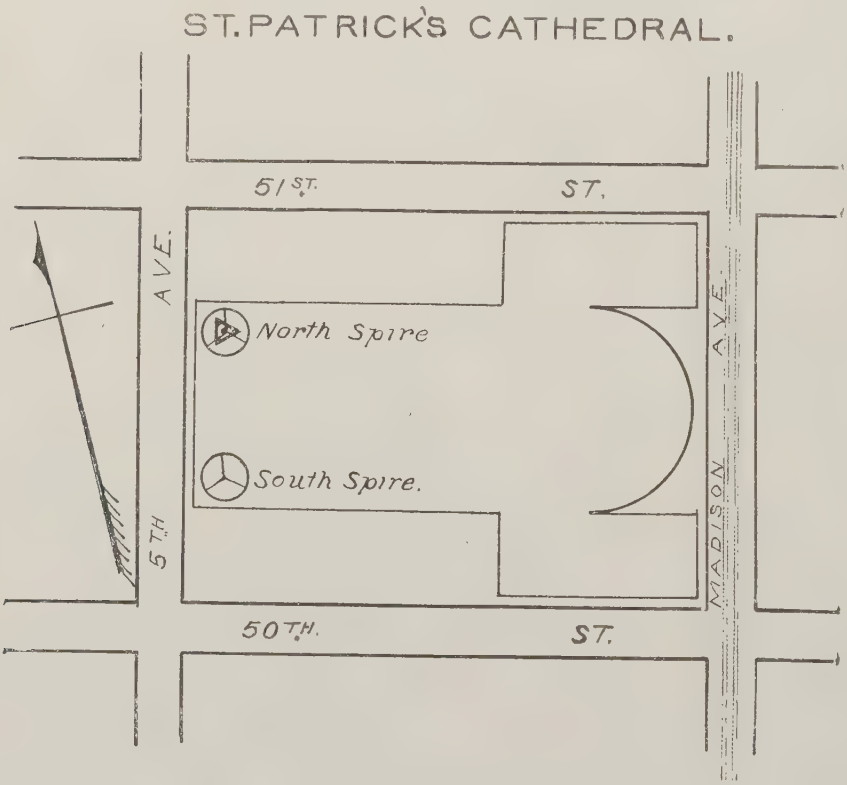
The station is a tertiary one and was not occupied.



ST. PATRICK'S CATHEDRAL.

This station is the north spire of St. Patrick's Cathedral, situated near the southeast corner of Fifth avenue and Fifty-first street, Borough of Manhattan, New York City, N. Y. The object sighted on is the base of the cross on top of the spire.

The station is a tertiary one and was not occupied.



No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
1	Bergen Dutch Reformed church	40 43 37.128	1145^{m}.2	74 04 04.372	102^{m}.6
			3757^{ft}.2		336^{ft}.6
2	Bergen Point lighthouse	40 38 34.636	1068^{m}.3	74 08 54.400	1278^{m}.2
			3504^{ft}.9		4193^{ft}.6
3	Constable Hook high chimney	40 39 03.571	110^{m}.2	74 05 40.341	947^{m}.8
			361^{ft}.5		3109^{ft}.6

NEW JERSEY.

POSITIONS.

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
288 56 16.28	108 58 36.60	Park Row building.....	5337m.94	3.7273736
			17512ft.89	
305 33 39.06	125 37 34.15	Prospect water tower....	10409m.05	4.0174111
			34150ft.36	
355 57 18.20	175 57 44.87	Fort Tompkins 2.....	13645m.04	4.1349749
			44767ft.11	
16 24 31.83	196 22 38.68	Bogart.....	14452m.09	4.1599308
			47414ft.91	
328 53 03.54	148 54 19.32	Bogart.....	5295m.26	3.7238875
			17372ft.87	
348 51 12.24	168 51 19.43	Quarry Hill schoolhouse.	1341m.51	3.1275934
			4401ft.27	
47 20 53.43	227 20 24.37	Summerfield church.....	1425m.32	3.1539118
			4676ft.23	
18 36 02.09	198 35 11.52	Bogart.....	5725m.26	3.7577951
			18783ft.62	
71 41 17.54	251 38 42.09	Summerfield church	5907m.88	3.7714319
			19382ft.77	
194 56 36.72	14 57 39.30	Bergen Dutch Reformed church....	8733m.88	3.9412071
			28654ft.40	
227 25 41.38	47 29 04.15	Park Row building.....	9915m.01	3.9962931
			32529ft.49	
257 26 46.67	77 31 44.12	Prospect water tower....	10984m.36	4.0407749
			36037ft.85	
328 06 18.25	148 07 47.40	Fort Tompkins 2.....	6092m.05	3.7847631
			19987ft.00	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
4	Highwood 2.....	40 46 12.674	$390^{m}.9$	74 01 02.078	$48^{m}.7$
			$1282^{ft}.4$		$159^{ft}.8$
5	North Hook beacon lighthouse.....	40 28 18.520	$571^{m}.3$	74 00 25.902	$610^{m}.3$
			$1874^{ft}.3$		$2002^{ft}.3$
6	Sandy Hook lighthouse	40 27 42.165	$1300^{m}.6$	74 00 08.682	$204^{m}.5$
			$4267^{ft}.1$		$670^{ft}.9$
7	Statue of Liberty.....	40 41 21.036	$648^{m}.9$	74 02 41.769	$980^{m}.8$
			$2128^{ft}.9$		$3217^{ft}.8$

NEW JERSEY.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
254 43 14.79	74 45 36.14	Memorial church.....	5260^{m}.55	3.7210314
			17259^{ft}.00	
338 54 41.24	158 56 37.52	Prospect water tower....	11634^{m}.50	4.0657476
			38170^{ft}.85	
353 16 38.75	173 17 00.16	Park Row building.. ...	6577^{m}.36	3.8180516
			21579^{ft}.22	
124 03 32.75	303 58 41.83	Great Kills.....	12724^{m}.35	4.1046355
			41746^{ft}.46	
143 44 27.95	323 41 00.56	Elm Tree.....	12695^{m}.86	4.1036622
			41653^{ft}.01	
147 30 32.47	327 26 17.62	Bogart.....	17162^{m}.48	4.2345800
			56307^{ft}.23	
164 10 28.07	344 08 32.68	Fort Tompkins 2.....	15305^{m}.21	4.1848393
			50213^{ft}.85	
340 06 32.01	160 06 43.17	Sandy Hook lighthouse.	1192^{m}.52	3.0764658
			3912^{ft}.46	
163 53 01.99	343 50 55.43	Fort Tompkins 2.....	16494^{m}.94	4.2173506
			54117^{ft}.14	
190 20 14.83	10 21 17.96	Centennial tower.....	12735^{m}.54	4.1050173
			41783^{ft}.18	
32 37 34.96	212 36 08.37	St. George schoolhouse.	5790^{m}.43	3.7627111
			18997^{ft}.44	
155 12 53.18	335 11 59.31	Bergen Dutch Reformed church ...	4624^{m}.10	3.6650274
			15170^{ft}.90	
231 36 22.08	51 37 48.47	Park Row building.....	3968^{m}.11	3.5985834
			13018^{ft}.71	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
7	Statue of Liberty—*Continued.*				
8	St. Peter's church	40 30 13.498	416^{m}.3 1365^{ft}.8	74 15 56.201	1323^{m}.3 4341^{ft}.5
9	Stephenson clock tower.	40 38 29.602	913^{m}.1 2995^{ft}.7	74 12 55.328	1300^{m}.0 4265^{ft}.1

NEW JERSEY.

POSITIONS—*Continued.*

Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
285 53 06.45	105 56 07.62	Prospect water tower ...	6786^{m}.83	3.8316669
			22266^{ft}.46	
307 29 42.17	127 30 46.99	Elevator	2943^{m}.75	3.4689012
			9657^{ft}.95	
350 05 45.43	170 06 11.49	Owl Head.....	5462^{m}.38	3.7373822
			17921^{ft}.16	
219 52 23.02	39 53 35.01	Kreusler	4068^{m}.58	3.6094427
			13348^{ft}.33	
221 19 44.97	41 21 34.42	Rossville	6002^{m}.93	3.7783636
			19694^{ft}.63	
232 31 01.47	52 33 59.12	Jessup.....	8107^{m}.39	3.9088811
			26599^{ft}.00	
240 06 20.02	60 08 17.77	Sharrot.....	4921^{m}.38	3.6920824
			16146^{ft}.06	
264 20 08.83	84 22 10.04	Princess Bay lighthouse.	4415^{m}.34	3.6449646
			14486^{ft}.01	
331 25 20.51	151 25 49.03	Great Beds lighthouse ..	2162^{m}.00	3.3348554
			7093^{ft}.16	
279 56 47.29	99 58 55.15	Summerfield church	4683^{m}.98	3.6706147
			15367^{ft}.35	
295 12 17.63	115 13 20.03	Old Place.....	2488^{m}.53	3.3959423
			8164^{ft}.44	
297 30 11.31	117 34 03.95	Bogart	9471^{m}.41	3.9764147
			31074^{ft}.12	
339 18 30.51	159 19 28.42	Linoleumville schoolhouse.	5920^{m}.27	3.7723416
			19423^{ft}.42	

No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
10	Woodbridge church spire	40 33 42.525	1311^{m}.7	74 16 26.030	612^{m}.4
			4303^{ft}.5		2009^{ft}.2

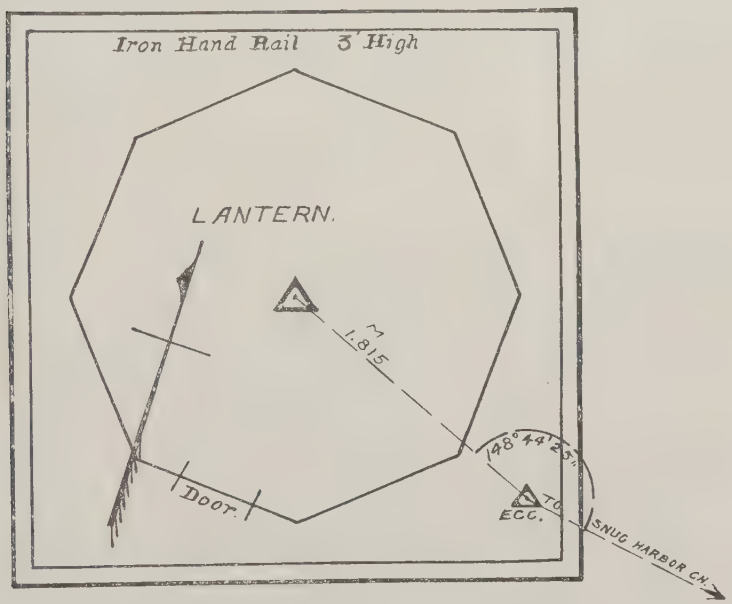
BERGEN POINT LIGHTHOUSE.

This station is the vane rod on Bergen Point Lighthouse, situated in the middle of the Kill von Kull, about midway off Port Richmond and Mariner's Harbor, Borough of Richmond, New York City, N. Y.

The eccentric station was established on the square iron platform surrounding the lantern. It was measured from vane rod to eccentric.

Reached by Elizabethport trolley to Mariner's Harbor; thence by boat to station.

BERGEN PT. LT. HO.



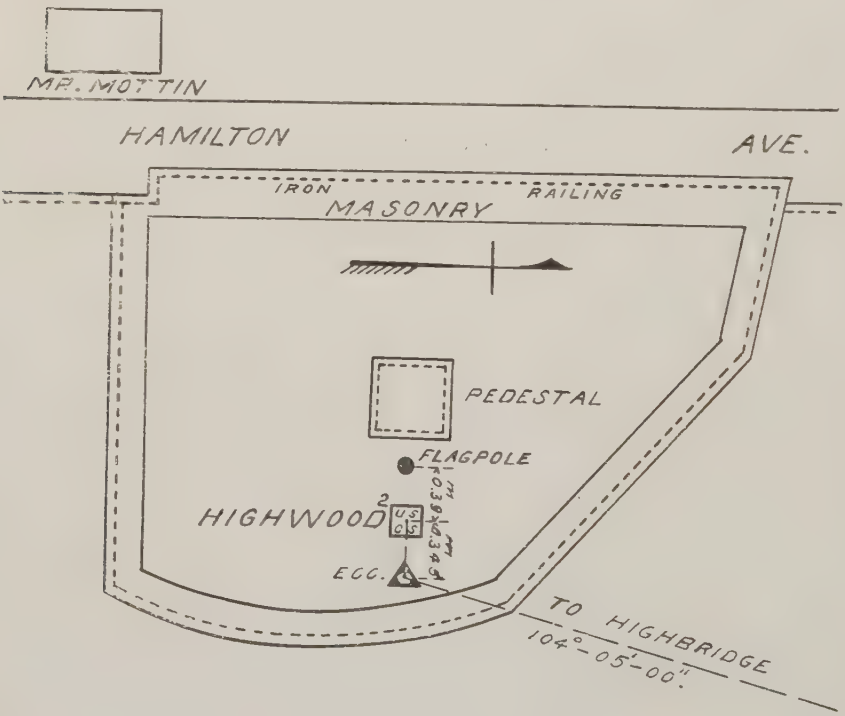
CONSTABLE HOOK CHIMNEY.

This station is the high brick chimney of the copper works at Constable Point, Bayonne, Hudson County, N. J.

HIGHWOOD 2.

This station is at Highwood Park, N. J., and is reached by Weekawken ferry from West Forty-second street, New York City, N. Y. It is about 150 feet south of the intersection of Boulevard Loop and Hamilton avenue, on the east side of the latter in line with West Forty-fourth street, Manhattan, and is on the property of Mr. Hugh N. Camp.

Found the marble capstone marked U. S. C. S. described by Messrs. Tittman and Bradford, but "×" on lead bolt is obliterated. The station is surrounded by a 1½-foot semi-circular ring about 2 feet high on which is an iron fence, and is on the sheer edge of the palisades. The key to the gate of the enclosure is in the custody of Mr. Mottin, directly opposite the station, on the west side of Hamilton avenue. A rock face, broken ashlar pedestal, 5 feet square and 5 feet high, has been built, 3 feet west of station. On this pedestal is a red sandstone boulder in which is sunk a bronze commemorative tablet. The boulder is surmounted by a bust of Alexander Hamilton. A 5½-inch flagpole about 30 feet high touches the west edge of the capstone and is 0.39 meter from the center of station.

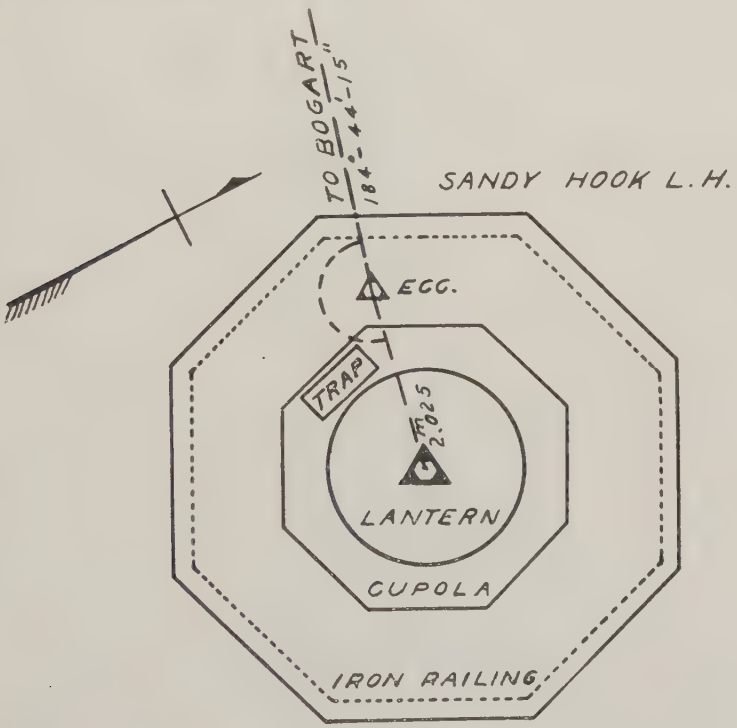


NORTH HOOK BEACON.

This station is a small lighthouse on the extreme northerly point of Sandy Hook, N. J. It is sometimes called Hook Beacon, and is 1192.52 meters north of Sandy Hook Lighthouse.

SANDY HOOK LIGHTHOUSE.

This station is the knob on top of the main lighthouse of Sandy Hook. The tower is octagonal in shape and is constructed of brick, painted white. The tower is surmounted by an octagonal cupola made of metal and glass with a flat pyramidal roof on the top of which is the station. It is in this cupola that the lantern is placed. The cupola is much smaller than the top of the brick tower, which has a copper covering and is surrounded by a light iron handrail. The center of the cupola was obtained by stretching strings from the corners and taking intersections so obtained.



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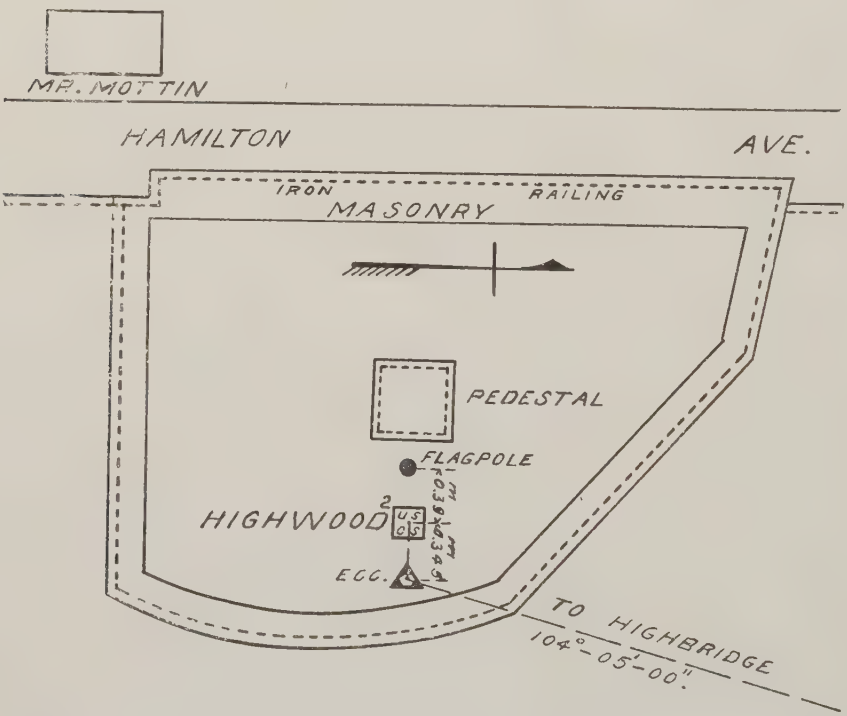

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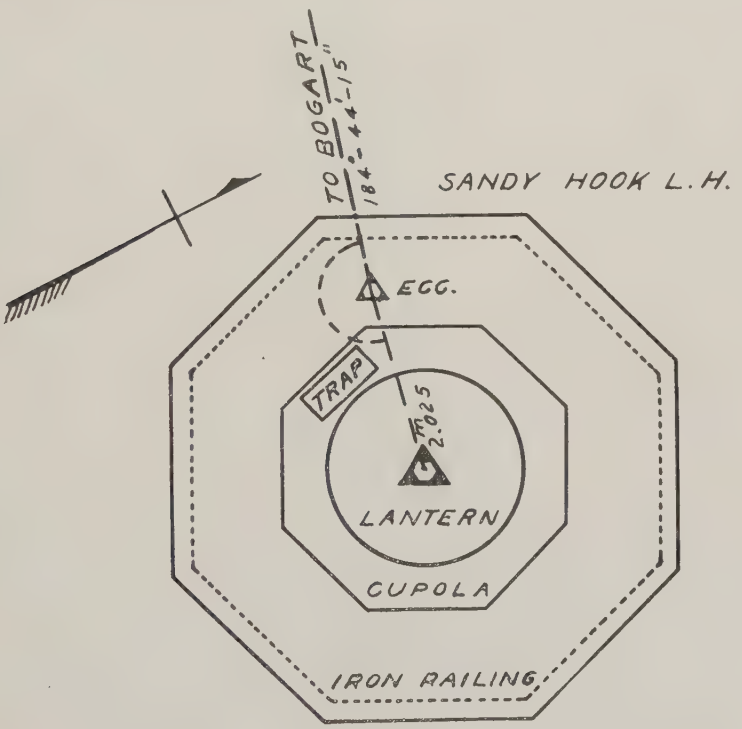


STATUE OF LIBERTY.

This station is the torch of the Statue of Liberty, on Liberty Island, in the upper bay of New York Harbor.

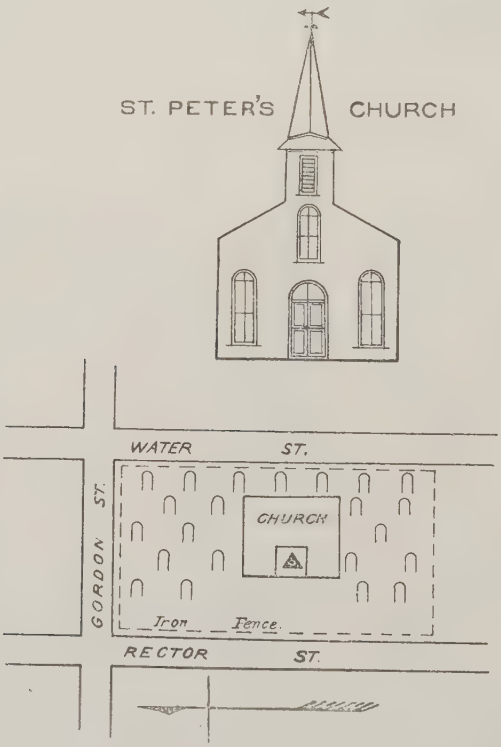
It is reached by passenger boat making regular trips from Battery Park New York City, N. Y.

ST. PETER'S CHURCH.

Station St. Peter's Church is the base of the vane rod on St. Peter's P. E. Church, Rector and Gordon streets, Perth Amboy, N. J.

The building is of brick; the spire is of wood, painted dark brown.

Reached by New Jersey Central R. R. to Perth Amboy, or by Staten Island R. R. to Perth Amboy.



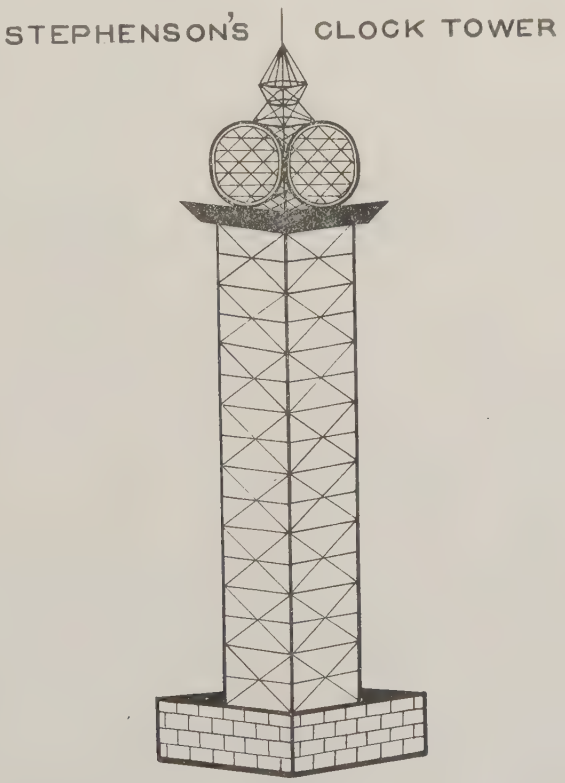
STEPHENSON CLOCK TOWER.

Station Stephenson Clock Tower is the pole on the large skeleton tower on Stephenson's Clock Works, foot of South Broad street, Elizabeth, N. J.

The plant is situated in vacant lots adjoining the Elizabeth Base Ball Club, on the outskirts of the city.

The tower was originally intended for a clock tower but was never finished. It is about 350 feet in height and has four skeleton dials on a square tower. Above the dials is an ornamental design whose top is conical.

Reached by Jersey Central or Pennsylvania R. R. to Elizabeth, N. J.; thence by South Broad street car to end of line. Walk south about 3,000 feet to station.



WOODBRIDGE CHURCH.

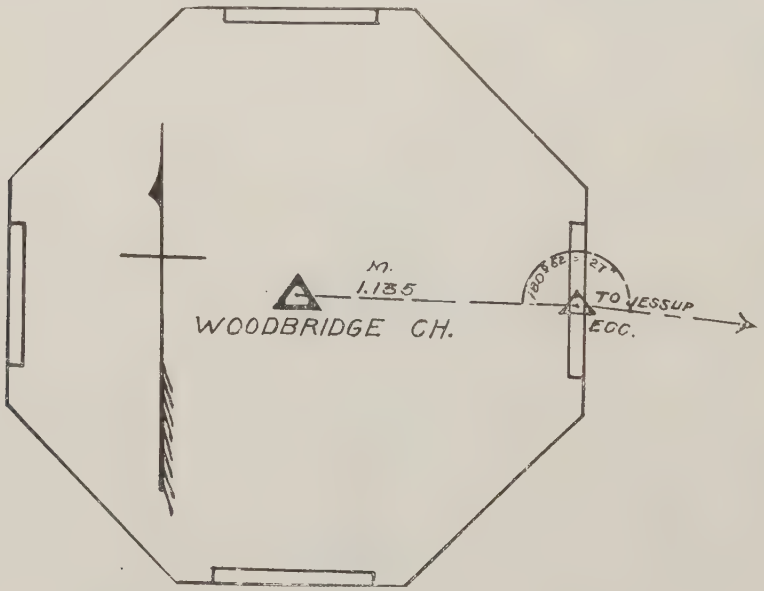
This station is the weather vane on the spire of the First Presbyterian Church, situated on Rahway avenue, Freeman street and Cataret road, Town of Woodbridge, N. J.

The church is frame, mansard roof, with tall spire, on top of which is weather vane with large gilt ball.

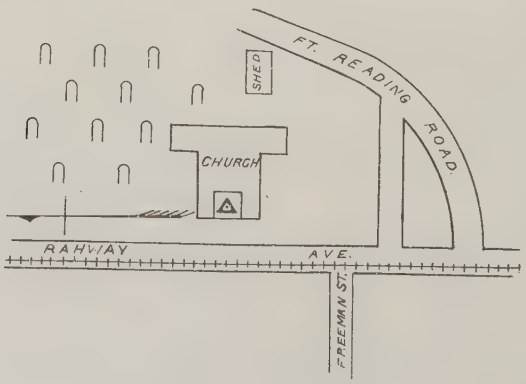
The center of weather vane was dropped to floor of spire by means of transit, and center marked with brass tack.

Eccentric station was established 1.135 meters east of center, and instrument was mounted on board placed on window sill from which all observations were made.

The station is reached by New Jersey Central R. R. from Jersey City to Sewaren; thence by trolley to church.



WOODBRIDGE CHURCH



No.	Stations.	Latitude. ° ′ ″	Length of Seconds.	Longitude. ° ′ ″	Length of Seconds.
1	Garden City cathedral..	40 43 16.408	$506^{m}.1$	73 38 32.582	$764^{m}.7$
			$1660^{ft}.4$		$2508^{ft}.9$
2	Spinney church.....	40 47 01.506	$46^{m}.5$	73 42 52.010	$1219^{m}.5$
			$152^{ft}.6$		$4001^{ft}.0$

COUNTY.

POSITIONS.

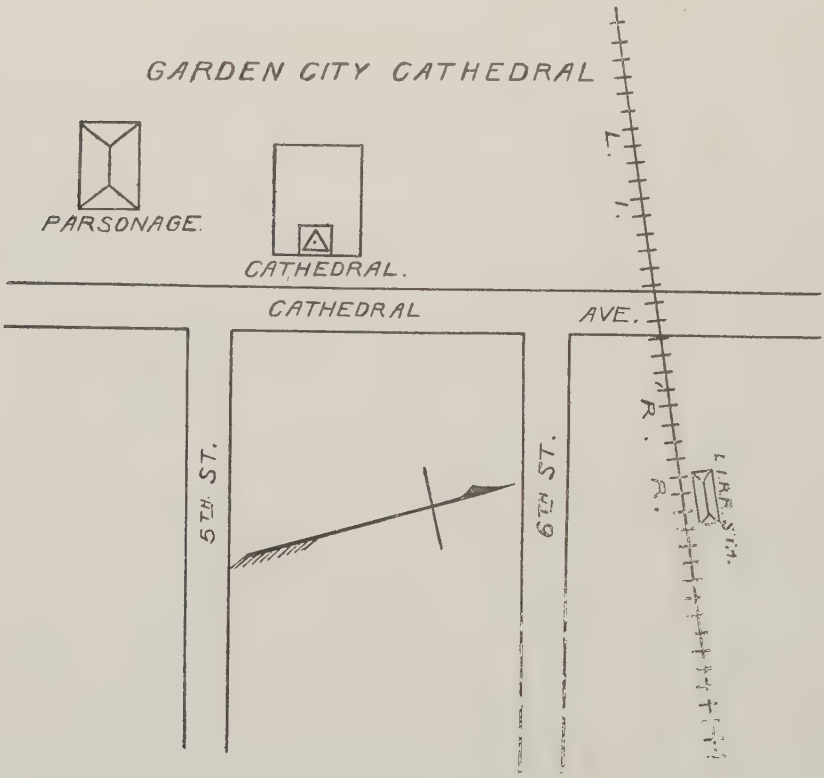
Azimuth. ° ′ ″	Back Azimuth. ° ′ ″	To Stations.	Distance.	Logarithms.
35 06 26.09	215 02 13.16	Far Rockaway schoolhouse	15867^{m}.22	4.2005008
			52057^{ft}.70	
53 20 42.10	233 15 49.92	Jager	13125^{m}.63	4.1181202
			43063^{ft}.00	
83 07 16.94	263 04 00.38	Belmont	7124^{m}.28	3.8527409
			23373^{ft}.58	
90 51 53.79	270 47 03.99	Hollis	10426^{m}.65	4.0181449
			34208^{ft}.10	
121 52 00.74	301 48 59.36	Payne	7676^{m}.51	3.8851637
			25185^{ft}.35	
8 31 56.02	188 31 43.94	Payne	2925^{m}.92	3.4662620
			9599^{ft}.46	
32 33 32.04	212 31 31.42	Hollis	8058^{m}.64	3.9062618
			26439^{ft}.05	
46 50 32.72	226 49 04.04	Taylor	4367^{m}.03	3.6401859
			14327^{ft}.50	
80 43 01.45	260 40 14.50	Bayside	6074^{m}.06	3.7834794
			19927^{ft}.98	
91 48 57.59	271 44 55.66	Whitestone schoolhouse	8689^{m}.14	3.9389766
			28507^{ft}.62	
115 35 24.74	295 31 21.32	Jackson	9679^{m}.51	3.9858532
			31756^{ft}.86	

GARDEN CITY CATHEDRAL.

Station Garden City Cathedral is the gilt cross on the spire of the Cathedral of the Incarnation, Cathedral avenue, Garden City, Nassau County, N. Y.

The building is of brown stone. The spire is very tall and corrugated all the way to the top.

Reached by L. I. R. R. to Garden City.

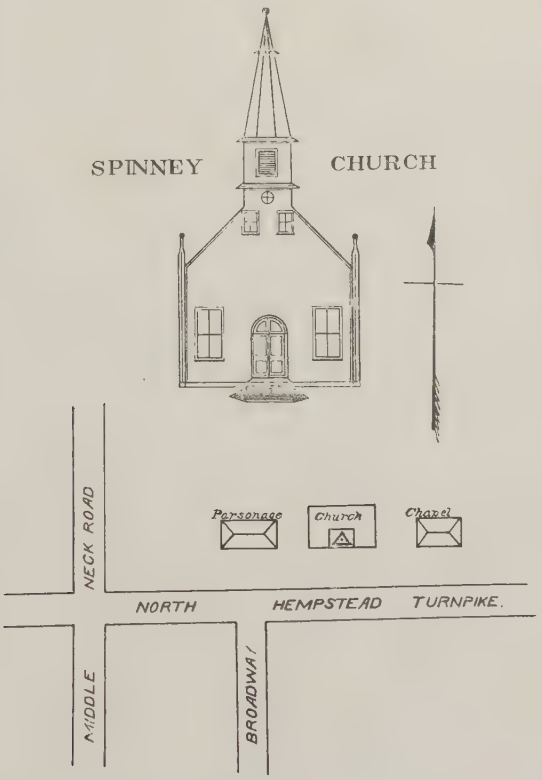


SPINNEY CHURCH.

Station Spinney Church is the center of the large white wooden ball on the spire of Spinney Memorial M. E. Church, North Hempstead turnpike and Broadway, Great Neck, Nassau County, N. Y.

The building is built of wood, painted white. It is not very high, the distance to the top of the spire being about 70 feet.

Reached by L. I. R. R. from Long Island City to Great Neck; thence by hack to church.



The foregoing finishes my report of the field work of the triangulation of Greater New York.

Respectfully submitted,

A. T. MOSMAN,
Assistant U. S. Coast and Geodetic Survey.
In charge of Triangulation.

Report on the Computation

OF THE

Triangulation of Greater New York

By JOHN F. HAYFORD

Chief of Computing Division U. S. Coast and Geodetic Survey

REPORT ON THE COMPUTATION OF THE TRIANGULATION OF GREATER NEW YORK.

By JOHN F. HAYFORD, Chief, Computing Division, Coast and Geodetic Survey.

Mr. O. H. TITTMANN,
Superintendent, Coast and Geodetic Survey:

SIR—I respectfully submit the following report on the office computation of the triangulation of Greater New York. This computation was made under my direction as Chief of the Computing Division, in accordance with the agreement of co-operation between the Coast and Geodetic Survey and the City of New York. The computations were commenced in February, 1904, and finished in December, 1908, being made as promptly as feasible after each portion of the field work was completed.

Seventeen different computers were, at different times, engaged upon this computation, namely: Messrs. A. L. Baldwin, H. C. Mitchell, C. R. Duvall, R. M. Packard, L. L. Ansart, R. Y. Ferner, L. J. Young, W. F. Reynolds, H. M. Armstrong, C. H. Mallison, R. B. McClenon, G. C. Baldwin, M. M. Blackburn, A. W. Winslow, G. B. Canaga, W. H. Dennis and E. H. Bowen. All but two of these computers had previous experience in computations in the Coast and Geodetic Survey. Seven of these computers are now in the Computing Division of the Coast and Geodetic Survey. For the direction of the details of the computation I have depended largely upon Mr. A. L. Baldwin and have also depended largely upon his skill and judgment in deciding doubtful questions, in fixing the order in which points were to be adjusted, and in fixing the number of equations and in selecting the particular equations to be involved in each separate adjustment. Messrs. A. L. Baldwin, Mitchell, Duvall, Packard and Ansart did about three-fourths of all the computing, the other twelve computers having each served for a short time only.

There were received from the City of New York the original records of observation, the original descriptions of stations, and field computations consisting of abstracts of angles, computations of eccentric reductions, lists of directions, and computations of lengths of triangle sides. The field computations did not include any adjustment by least squares.

The office computations, made at Washington, consisted of abstracts of angles, eccentric reductions, local adjustments, lists of directions, figure adjustments made by least squares, computations of lengths of triangle sides, computations of geographic positions (that is, latitudes and longitudes, with lengths and azimuths) and of rectangular linear co-ordinates. The abstracts, eccentric reductions and lists of directions made at Washington consist in part of revisions of the field computations and in part of new computations. The remaining office computations are all new. In all of the office computations the methods of the Coast and Geodetic Survey were followed, including requirements which insure that every part of the computation shall be thoroughly checked.

During the progress of the computations, geographic positions, including lengths and azimuths, and rectangular linear co-ordinates of points were furnished from time to time to the Chief Engineer of the Board of Estimate and Apportionment for the use of the topographic bureaus in the different boroughs.

At the close of the work there was delivered to the Chief Engineer of the Board of Estimate and Apportionment the original records of observations, original descriptions of stations and one complete set of computations, including lists showing the final results of the computation, namely, latitudes and longitudes, azimuths and lengths and rectangular linear co-ordinates.

Abstracts and Local Adjustments.

Starting from the record books, the first step of the office computation is the making or checking of abstracts of angles. These abstracts show the separate values of each angle derived from each set of repetitions (usually 12) with a repeating theodolite, or from each observation with a position theodolite, the mean values of the angles, the corrections to close the horizon, the corrections to reduce to center of station (eccentric reduction), and the corrected angles after the corrections named have been applied.

In each case in which the position of the theodolite, or of the object observed upon, was not coincident with the triangulation station, it was necessary to make computations referred to above, and known as eccentric reductions, to determine the corrections to be applied to the observed angles to reduce them to the values which they would have had if the theodolite and object observed upon had been coincident with the triangulation stations. These computations are based upon the observed direction and distance from the eccentric point used to the triangulation station. In this New York triangulation, on account of the numerous stations necessarily placed on roofs, water towers, etc., there was an unusually large number of eccentric reductions to be made.

Examples of abstracts of angles and of eccentric reductions are shown in the report on the field work of this survey written by Assistant A. T. Mosman.

In each case, in which the program of observation at a station was simply that indicated in the report on field work referred to in the preceding paragraph the only rigid condition between the observed angles at a station being the horizon closure, no local adjustment was necessary other than the distribution of the horizon closure which was made on the abstract of said angles. At 18 stations, out of a total of 146 stations occupied, it was found that from one to four other rigid conditions had been introduced. These cases occurred frequently at stations occupied at two or more different times. These new rigid conditions, namely, either an additional closure of the horizon or the condition that a certain observed angle was necessarily the sum of two or more other observed angles made a local adjustment necessary. This adjustment was made by the regular method of the Coast and Geodetic Survey.

EXAMPLE OF LOCAL ADJUSTMENT.

Seaside Hotel.

List of Observed Angles.

	Observed Angles. ° ′ ″	No. of Sets.	Corrections.	Seconds of Corrected Angle. ″
Centennial Tower to School-house Avenue K	30 16 32.19	4	$V_1 = +0.32$	32.51
School-house Avenue K to Bergen Beach Casino	5 21 53.56	3	$V_2 = +0.51$	54.07
School-house Avenue K to Prospect Water Tower	13 35 49.48	4	$V_3 = -0.20$	49.28
Prospect Water Tower to Ridgewood G. H.	26 04 51.31	4	$V_4 = -0.20$	51.11
Bergen Beach Casino to Aqueduct School-house	57 06 52.66	3	$V_5 = +0.51$	53.17
Ridgewood G. H. to Hollis	43 04 13.33	4	$V_6 = -0.20$	13.13
Aqueduct School-house to Idlewild	25 20 18.80	3	$V_7 = +0.51$	19.31
Far Rockaway School-house to Centennial Tower	193 58 41.99	4	$V_8 = +0.32$	42.31
Far Rockaway School-house to Life Saving Station, Rockaway Point	173 33 07.62	3	$V_9 = -0.17$	07.45
Barren Island School-house to School-house, Avenue K	26 20 15.69	3	$V_{10} = -0.17$	15.52
Hollis to Far Rockaway School-house	52 59 51.86	4	$V_{11} = -0.20$	51.66
Idlewild to Far Rockaway School-house	47 52 38.11	3	$V_{12} = +0.52$	38.63
Life Saving Station Rockaway Point, to Barren Island School-house	24 21 52.03	3	$V_{13} = -0.18$	51.85

List of Directions.

	Observed Directions. ° ′ ″	Correction.	Corrected Directions. ″
Centennial Tower	0 00 00.00	.....	00.00
Barren Island School-house	3 56 16.50	$+V_1-V_{10}$	16.99
School-house Avenue K	30 16 32.19	$+V_1$	32.51
Bergen Beach Casino	35 41 25.75	$+V_1+V_2$	26.58
Prospect Water Tower	43 52 21.67	$+V_1+V_3$	21.79
Ridgewood G. H	69 57 12.98	$+V_1+V_3+V_4$	12.90
Aqueduct School-house	92 48 18.41	$+V_1+V_2+V_5$	19.75
Hollis	113 01 26.31	$+V_1+V_3+V_4+V_6$	26.03
Idlewild	118 08 37.21	$+V_1+V_2+V_5+V_7$	39.06
Far Rockaway School-house	166 01 18.01	$-V_8$	17.69
L. S. S. Rock. Point	339 34 25.63	$-V_8+V_9$	25.14

Condition Equations.

No. 1 $0= -0''.16-V_1-V_3-V_4-V_6-V_8-V_{11}$

No. 2 $0= -2''.69+V_1+V_2+V_5+V_7+V_8+V_{12}$

No, 3 $0= -1''.16+V_1+V_3-V_9-V_{10}-V_{13}$

TABLE OF CORRELATES.

	12/p.	C_1.	C_2.	C_3.
V_1	3	—1	+1	+1
V_2	4		+1	
V_3	3	—1		
V_4	3	—1		
V_5	4		+1	
V_6	3	—1		
V_7	4		+1	
V_8	3	—1	+1	+1
V_9	4			—1
V_{10}	4			—1
V_{11}	3	—		
V_{12}	4		+1	
V_{13}	4			—1

NORMAL EQUATIONS.

$$O = -0''.16 + 18C_1 - 6C_2 - 6C_3.$$
$$O = -2''.69 - 6C_1 + 22C_2 + 6C_3.$$
$$O = -1''.16 - 6C_1 + 6C_2 + 18C_3.$$

$$C_1 = +''.0663.$$
$$C_2 = +\ .1284.$$
$$C_3 = +\ .0437.$$

The angles given as observed in the first list are those resulting directly from the observations save that the eccentric reduction, to the triangulation stations from the eccentric stations occupied, have been applied. The number of sets of 12 repetitions each on each angle is indicated. The V's given are the corrections derived from the local adjustment. The last column of the list shows the corrected angles after applying the corrections (V's).

The observed directions, as given in the list of directions above, are fixed by the observed angles, ignoring for the moment the last three in the list of angles, these being the three which introduce rigid conditions to be satisfied. The next column in the list of directions gives the corrections expressed in the same notation as in the list of observed angles. Thus the direction to Bergen Beach Casino referred to Centennial Tower being the sum of the first and second angles in the list of angles, the correction to this direction is $+ V_1 + V_2$.

The first and second condition equations each express the condition that the sum of certain angles must be exactly 360 degrees in order to close the horizon. The sum of the angles as observed is 0″.16 too large in the first case and 2″.69 too small in the second case. The third condition equation expresses the condition that the sum of the first and eighth angles must be the same as the sum of the ninth, tenth and thirteenth, since, in each case, the sum is the angle between Far Rockaway School House and School House Avenue K. The sums, of the observed angles indicated, differ by 1″.16.

The least square adjustment required at this station is one which shall furnish that one of the infinite number of sets of corrections $V_1, V_2, V_3, \ldots V_{13}$ which will satisfy the three conditon equations for which the sum of the squares of the corrections is less than for any other set.

The usual practice is to treat such a least square adjustment by the method of correlates. For the explanation of this method, consult any good text book on least squares.

The tables of correlates, as given above, shows the usual arrangement of the correlate equations in computations made in the Coast and Geodetic Survey. The quantities in the second column of the table are inversely proportional to the weights (p) which have been assigned to each angle. The assigned weights are proportional to the number of observations of each angle. The first line of the table may be read thus:

$$3 V_1 = - C_1 + C_2 + C_3.$$

Similarly, the second line may be read

$$4 V_2 = C_2$$

and so on.

The normal equations as given are derived from these correlate equations and the condition equations.

The solution of the normal equations gave the values shown for C_1, C_2, and C_3. These values being substituted in the correlate equations represented by the table of correlates gave the V's, which are the required corrections to the angles, and from which the required

corrections to the directions were obtained as indicated in the list of directions.

Next in the regular order of computations after the abstract of angles, eccentric reductions, and local adjustments come the lists of directions for each station, an example of which in the usual form is given in the report on the field work of this survey written by Assistant A. T. Mosman. Such a list shows for each station the direction of every observed line from that station, expressed as an angle, counted in the clockwise direction from one line adopted as the initial. The angles from the adopted initial, known as directions, are obtained by the use of the locally adjusted angles. The list of directions therefore shows the results of the abstracts, eccentric reductions and local adjustments at the station independently of observations at any other station. In the list of directions a second column, for the seconds of the direction only, is provided, under the heading "Final seconds" in which the final results of the adjustment of the triangulation by least squares are shown. The least square adjustment here referred to is that known as the figure adjustment in which the relations of the angles observed at each station to those observed at surrounding stations are taken into account and the necessasry corrections to the angles at each station to close all triangles and to remove all length discrepancies are derived.

The computed lengths of all lines in the triangulation of New York City depend entirely upon two bases measured in connection with the triangulation and known as the Ocean Parkway Base and the Unionport Base.

The office computation of these bases dealt with the standardization of the tapes as well as the base measurements proper. It included all corrections necesssary to take account of the actual lengths of the tapes, the temperatures at which the base measurements were made, the inclination to the horizon of each tape length and the elevation of the measured line above sea level.

The length of the Ocean Parkway Base Line is 3940.9117 meters = 12929.4746 feet and its probable error is only ± 7.54 millimeters or 1 part in 523000.

The length of the Unionport Base Line is 3643.4675 meters = 11953.6097 feet and its probable error is only ± 6.15 millimeters or 1 part in 592000.

In this as in other similar cases in the Coast and Geodetic Survey, the lengths of the bases are determined with a degree of accuracy so much higher than the accuracy which can be maintained in the triangulation, even through a single figure, that in the adjustment of the triangulation, the lengths of the bases are considered as absolutely fixed by the base measurements and the triangulation is, therefore, adjusted to fit each base in so far as lengths are concerned.

A Figure Adjustment Necessary.

Any computation of this triangulation made directly with the observed angles at each station as shown in the lists of directions would

show three kinds of discrepancies. First, the sum of the angles of each triangle would differ from 180° plus the spherical excess, this being the absolutely known value of the sum of the angles of the triangle. Second, any computation of triangle sides started from a fixed length for one line of the triangulation, Ocean Parkway Base for example, and carried through two different chains of triangles arbitrarily selected would show two computed lengths differing from each other for each line common to the two chains of triangles. Third, the length of the Unionport Base, as computed through the triangulation from the Ocean Parkway Base, would differ from its measured length, the difference being much greater than the maximum amount which may possibly be due to errors in the base measurements.

These discrepancies would not exist if the angles were observed absolutely without error. These discrepancies are both a measure of the accuracy of the observed angles and an indication of the corrections which should be applied to the observed angles to obtain the true angles. The purpose of the adjustment of the triangulation by the method of least squares is to determine from all the evidence available the most probable set of corrections to the observed angles and thus to give computed results which are probably the closest approximations to the truth that can be derived from the observations. The fundamental assumption in the method of least squares as applied to this case is that the most probable set of corrections to the observed angles is that one of the infinite number of sets of corrections which will each remove all of the discrepancies of the three classes stated for which the sums of the squares of the corrections is less than for any of the other sets. This least square method of computation, the best known method of computing triangulation, was used in the computation of the Greater New York triangulation in accordance with the regular practice of the Coast and Geodetic Survey. An example of the method and some information in regard to the manner in which it was applied to the Greater New York triangulation are given later in this report. For complete information in regard to the theory of the method, one must consult a good text book on least squares, or the adjustment of observations.

Computation of Lengths.

The next step after the least square adjustment, namely, the computation of the lengths of all lines determined by the triangulation, is illustrated by the following example:

COMPUTATION OF TRIANGLES.

Nos. of Directions.	STATIONS.	Observed Angles. ° ′ ″	Correction. ″	Spherical Angles. ″	Spherical Excess. ″	Plane Angles. ″	Logarithms.
		Jackson—Ludlow.	.....	.....	.....	.....	3.6460219
—29+32	Straus.....	40 22 24.18	—1.85	22.33	.02	22.31	0.1885865
—11+15	Jackson.....	62 18 30.92	— .20	30.72	.02	30.70	9.9471703
— 1+ 4	Ludlow.....	77 19 07.91	— .89	07.02	0.03	06.99	9.9892744
			—2.94		0.07		
		Straus—Ludlow.	.....	.....	.....	.....	3.7817787
		Straus—Jackson.	.....	.....	.....	.....	3.8238828
		Crosby—Protectory.	.....	.....	.....	.....	3.4991733
—30+31	Straus.....	35 28 01.97	— .29	01.68	.01	01.67	0.2363954
—20+21	Crosby.....	49 18 19.55	+1.07	20.62	.01	20.61	9.8797835
—22+24	Protectory.....	95 13 36.78	+ .95	37 73	.01	37.72	9.9981902
			+1.73		0.03		
		Straus—Protectory.	.....	.....	.....	.....	3.6153522
		Straus—Crosby.	.....	.....	.....	.....	3.7337589

Nos. of Directions.	STATIONS.	Observed Angles. ° ′ ″	Correction. ″	Spherical Angles. ″	Spherical Excess. ″	Plane Angles. ″	Logarithms
		Crosby—Ludlow.	.. ...	.....	.....	.....	3.5615149
—30+32	Straus	36 31 29.85	—1.38	28.47	.01	28.46	0.2253608
—19+21	Crosby.....	81 14 20.53	— .25	20.28	.02	20.26	9.9949030
— 1+ 3	Ludlow	62 14 10.79	+ .51	11.30	.02	11.28	9 9468832
			—1.12		0.05		
		Straus—Ludlow.	.....	.....	.....	.....	3.7817787
		Straus—Crosby.	.....	.....	.....	.....	3.7337589
		Protectory—Ludlow.	.....	.....	.....	.....	3.2851544
—31+33	Straus	1 03 27.88	—1.086	26.794	.....	26.794	1.7338904
+22—27	Protectory.....	176 40 49.99	— .927	49.063	.001	49.062	8.7627329
— 1+ 2	Ludlow	2 15 45 30	—1.156	44 144	.....	44.144	8.5963075
			—3.17		0.001		
		Straus—Ludlow.	.....	.....	.....	.....	3.7817787
		Straus—Protectory.	.....	.....	.....	.....	3.6153523

The above example shows the computation for four triangles in the Unionport Base figure, for which the figure adjustment by the method of least squares is shown later in this report.

In the first column are given the numbers of the two directions, as shown in the sketch on page 395, of which the difference is the observed angle shown in the third column. In the first triangle, Straus-Jackson-Ludlow, the observed angle at Straus is written in the third column opposite the name Straus in the second column, and, similarly, for the observed angles of the triangle at Jackson and Ludlow.

The fourth column shows the corrections to each angle derived from the least square adjustment of the figure. The algebraic sum of these three corrections for any triangle (as shown just below the three corrections) is necessarily the error of closure of the triangle. The fifth column shows the spherical angles, so called because each is the angle of a spherical triangle, obtained by applying the correction in the fourth column to the angle in the third column.

The sixth column shows the correction to each angle for spherical excess, namely, one-third the spherical excess for the triangle. In every spherical triangle the excess of the sum of the three angles over 180 degrees bears the same ratio to eight right angles as the area of the triangle bears to that of the whole sphere. The triangles concerned in such a triangulation as this are really upon a spheroid, not a sphere. But it is known that, with a degree of accuracy far within the limits of possible accuracy of observation the spheroidal angles and the spherical angles may be considered as equal, the radius of the sphere being assumed to be that which will make it fit most closely to the part of the spheroid concerned. The exact formula used in computing the spherical excess and a table of factors for use with it are given on pages 290, 291 of Appendix 9 of the Coast and Geodetic Survey Report for 1894. The following rule is sufficiently exact for any of the triangles involved in the triangulation of Greater New York. The spherical excess of any triangle, expressed in seconds, is equal to the area of the triangle expressed in square statute miles, divided by 76.1.

The spherical excess in the sixth column being subtracted from the spherical angle in the fifth column gives the plane angle shown in the seventh column. It is known that in any plane triangle having such angles as are shown in the seventh column the ratios of the sides (straight lines) are the same as the ratios of the sides (curved lines) of the spherical triangle having the angles shown in the fifth column. Hence the plane triangles may be solved by using the rule that the ratio of any two sides is the same as the ratio of the sines of the opposite angles, and the results secured will be the lengths of the sides of the spheroidal triangles.

The eighth column shows how the computations depending upon the proportionality of sines and sides are made. The logarithm 3.6460219 is the logarithm of the length (in meters) of the line Jackson-Ludlow as fixed by previous computations, which length is to be used as the known side of the triangle Straus-Jackson-Ludlow. The logarithm 0.1885865 is the logarithm of the cosecant (reciprocal of the

sine) of the plane angle at Straus, namely, 40° 22′ 22.31″. The logarithm 9.9471703 is the logarithm of the sine of the plane angle at Jackson, namely, 62° 18′ 30.70″, and, similarly, 9.9892744 is the logarithm of the sine of 77° 19′ 06.99″. The logarithm of the length Straus-Ludlow, namely, 3.7817787, is obtained by adding the first, second and third logarithms. The logarithm of the length Straus-Jackson, namely, 3.8238828, is obtained by adding the first, second and fourth logarithms. Note that in this arrangement of the computation, the angle of the triangle given first, and of which the logarithm of the cosecant is taken, is the angle opposite the known side, for example, the angle Straus, opposite the known side, Jackson-Ludlow.

It should be noted that by the computation of any length from two or more triangles, as for example, Straus-Ludlow, from the first and third triangles shown, a check is obtained on the figure adjustment by least squares. For the logarithms of the lengths resulting from the computation should not differ except by the effect of omitted decimal places which seldom exceeds one in the seventh decimal place.

Lengths and Geographic Positions.

The lengths obtained from these computations are distances from station to station measured on the sea level surface along the shortest line in that surface joining the points which are vertically below the stations. These are, therefore, distances measured along lines, which lie in vertical planes but are curved in those planes, the radii of curvature being that of the sea surface or approximately 4,000 miles (6,400 kilometers). These are the distances ordinarily computed from triangulation and utilized in all geodetic operations.

The traverses to be controlled by this triangulation are not reduced to sea level. They are simply reduced to the horizontal. Hence, there is a theoretical difference between the traverse distance and the distance given by the triangulation. This theoretical difference is, however, so small that it is not advisable to introduce extra complications into the computations to take it into account. To reduce the sea level distance, as given by the triangulation, to the distance actually measured in a traverse it is theoretically necessary to add a correction

$$=(\text{length of line})\frac{(\text{mean elevation of traverse above sea level, in meters})}{6370000}$$

The denominator, 6370000, is the mean radius of curvature of the sea level surface at Greater New York. If the maximum mean elevation at which any traverse may be measured in Greater New York is 116 meters (= 381 feet) the maximum value of the above correction is $\frac{1}{55000}$ part of the length. For traverses measured at a lower mean elevation than 381 feet the theoretical correction is proportionally smaller than $\frac{1}{55000}$.

The next step, after the triangle side computation, which fixes all distances, was to compute the geographic positions. The latitude and longitude of one point being known and the azimuth of one line from it to an adjacent point, and all angles and distances being known, the position computation serves to determine the latitude and longitude of each point in the scheme of triangulation, and the azimuths of lines joining the points. The formulae and the methods of making these computations are given in full with the necessary factors in Appendix 9 of the Coast and Geodetic Survey Report for 1894, "Formulae and Factors for the Computation of Geodetic Positions."

The comptations as made, like all such computations now made in the Coast and Geodetic Survey, are based upon the Clarke spheroid of 1866 as expressed in metric units, namely,

a = equatorial radius = 6378206.4 meters
b = polar semi-diameter = 6356583.8 meters
$\frac{a-b}{a}$ = flattening = $\frac{1}{294.98}$

The position computations for Greater New York were placed upon the United States Standard Datum of the Coast and Geodetic Survey by starting the position computation with the value 40° 36′ 15.867″ for the latitude of Fort Tompkins 2 and 74° 03′ 23.433″ for its longitude and with the azimuth 343° 50′ 55.43″ for the line Fort Tompkins 2 to Sandy Hook Light House. These are values fixed by the triangulation of the Coast and Geodetic Survey in this vicinity, which is connected with other triangulation extending continuously over a considerable part of the United States to Maine, Texas, Florida, Minnesota, California and Washington.

The fact that the latitudes, longitudes and azimuths are computed upon the United States Standard Datum make them directly comparable with geographic positions determined elsewhere by the Coast and Geodetic Survey and thus fixes the positions of the New York City points with respect to many thousands of points widely scattered over the United States. It also insures that each computed latitude depends upon astronomic observations of latitude at many stations scattered widely over the United States and that the computed latitudes are, therefore, a close approach to the true geodetic values. A similar statement applies to each computed longitude and each computed azimuth. For a full explanation of the United States Standard Datum and the reasons for adopting it in the work of the Coast and Geodetic Survey, see pages 873-875 of Appendix 4 of the Coast and Geodetic Survey Report for 1903, "Triangulation Southward along the Ninety-eighth Meridian in 1902."

The latitudes, longitudes, and azimuths and the lengths given with them are the ultimate standards with which all other data are to be tested. In computing the latitudes, longitudes, azimuths and the lengths given with them, all approximations made are far within the limits of accuracy of the observations.

Rectangular Linear Co-ordinates.

On the other hand, in the computation of the rectangular linear co-ordinates assumptions are made which are not in accordance with the facts and which introduce errors into the computation which may, in extreme cases, be appreciable. In computing rectangular linear co-ordinates it is assumed that the surface to which all traverses are referred when the measurements are reduced to the horizontal is a plane surface and as a corollary that all meridians are parallel. As a matter of fact, when a traverse is simply reduced to the horizontal from the inclined lines along which it is measured it is referred to a spheroidal surface similar to the sea level surface. The lengths and angles represented by the reduced traverses being upon this spheroidal surface and the computations being made as if they were upon a plane surface the computation distorts the facts, the distortion being that necessary to make certain portions of the spheroidal surface fit a plane. These distortions must be accepted as the price of the greater convenience of the rectangular co-ordinates for use in connection with city surveys. These distortions aside from the neglect of the convergence of meridians are, in general, less than the errors of the traverses to be controlled. Some information in regard to the amount of distortion is given later in this report.

The rectangular linear co-ordinates have been computed in accordance with the terms of the agreement of co-operation. The following example of the computation of the co-ordinates of Hollis and Taylor will serve to illustrate the manner in which the computation was made. The actual computations were arranged in a slightly different way on the page to secure greater compactness.

COMPUTATION OF RECTANGULAR LINEAR CO-ORDINATES OF HOLLIS REFERRED TO PROSPECT WATER TOWER AS THE ORIGIN.

Azimuth or bearing of line, Prospect Water Tower to Hollis = B = 251° 51′ 50″.32.

Log sin B.....	= 9.9778699	Log cos B.....	= 9.4931428
Log (distance in meters)	= 4.2541868	Log (distance in meters)	= 4.2541868
Log (X, in meters).....	= 4.2320567	Log (Y, in meters).....	= 3.7473296
X, in meters	= — 17063.051	Y, in meters.....	= + 5588.942
X, in feet.....	= — 55981.026	Y, in feet.....	= + 18336.387

COMPUTATION OF RECTANGULAR LINEAR CO-ORDINATES OF TAYLOR REFERRED TO PROSPECT WATER TOWER.

Bearing of line Hollis to Prospect Water Tower = 71° 51′ 50.32

Angle at Hollis between Prospect W. T. and Taylor = 124 48 16.00

Bearing of line Hollis to Taylor = B..... = 196 40 06.32

Log sin B.....	= 9.4576284	Log cos B.....	= 9.9813568
Log (distance in meters)	= 3.5993811	Log (distance in meters)	= 3.5993811
Log (part of X, in meters).....	= 3.0570095	Log (part of Y, in meters).....	= 3.5807379
Part of X, in meters...	= — 1140.275	Part of Y, in meters...	= + 3805.359
X of Hollis from above	= — 17063.051	Y of Hollis, from above	= + 5588.942
X of Taylor, in meters	= — 18203.326	Y of Taylor, in meters	= + 9397.301
X of Taylor, in feet...	= — 59722.078	Y of Taylor, in feet....	= + 30830.978

The co-ordinates of Hollis were computed in a single step from the origin Prospect Water Tower, whereas the co-ordinates of Taylor, which was not observed directly from Prospect Water Tower, were computed in two steps. The second of these computations is slightly different from the first, but a computation involving a third step from the origin would show no new features.

The bearing of the line Prospect Water tower to Hollis was taken directly from the lists of geographic positions being the azimuth from Prospect Water Tower to Hollis as there shown. This procedure may be followed for lines radiating from the origin but not for any other lines.

The logarithms of the distance Prospect Water Tower to Hollis, namely, 4.2541868 and of the distance Hollis to Taylor, namely, 3.5993811 were taken directly from the list of geographic positions.

The logarithms of X and Y in the first computation and "part of X" and "part of Y" in the second computation are in each case, the sum of the two logarithms shown just above.

The bearing of the line Hollis to Prospect Water Tower in the second computation is taken as 71° 51′ 50″.32 differing by exactly 180° from the bearing of Prospect Water Tower to Hollis, since, in the system of rectangular linear co-ordinates computed on a plane, the forward and backward bearing of any line necessarily differ by exactly 180°. The angle 124° 48′ 16″.00 at Hollis in the second computation was taken from the list of directions at Hollis, from the column headed final seconds. This is, therefore, the best available value for this angle after all corrections have been applied including the corrections due to the least square adjustment of the figure. Note that it is the spherical angle, the angle on which the observations were made, not the theoretical plane angle used in the computation of triangle sides.

The three triangulation stations used as origins for the computations of rectangular linear co-ordinates are for the Borough of The Bronx, Parkway, for the Boroughs of Queens and Brooklyn, Prospect Water Tower, and for the Borough of Richmond, Bogart. The co-ordinates are referred to the true meridian through the station used as an origin in each case.

The distance, D, between any two points whose rectangular co-ordinates referred to the same origin are X_1, Y_1, and X_2, Y_2 may be computed from the formula

$$D = \sqrt{(X_1 - X_2)^2 + (Y_1 - Y_2)^2}$$

In using this formula, as well as the one which follows, the algebraic signs of the X's and Y's must be taken into account.

Similarly, the bearing, B, according to the system of co-ordinates, of the line from the point X_1, Y_1 to the point X_2, Y_2 may be computed from the formula

$$\tan B = \frac{X_2 - X_1}{Y_1 - Y_2}$$

The bearing, B, as derived from this formula is counted in the clockwise direction from the south as zero, as the azimuths are reckoned in connection with the triangulation.

If logarithms are used it will be convenient to use the second of the above formulae at once to obtain B and then to compute D from one of the two formulae.

$$D = \frac{(X_2 - X_1)}{\sin B} \text{ and } D = \frac{(Y_1 - Y_2)}{\cos B}$$

To make the effect of omitted decimal places as small as possible use whichever one of these two formulae has the larger quantity in the parenthesis in each particular case.

Approximations in Computing Co-ordinates.

As already stated, the length and azimuth given in connection with the geographic positions are correct in so far as computation is concerned, that is, they involve no approximations in computation except such as are extremely small in comparison with the errors of observation. On the other hand, the computations of the rectangular linear co-ordinates involves approximations which are not always inappreciable. To introduce here a theoretical discussion of the errors of rectangular linear co-ordinates would greatly lengthen this report, and might indicate but imperfectly the possible magnitude of these errors in the concrete case of such co-ordinates as apply to Greater New York. It is believed that the following six selected comparisons between lengths and azimuths as computed from the rectangular linear co-ordinates and the true lengths and azimuths computed in connection with the geographic positions will serve to indicate with sufficient accuracy and in a concrete manner the possible magnitude of the errors. These six cases have been selected as being those in which the errors are probably a maximum. They were selected, however, merely by an examination of the triangulation sketch and the computation of co-ordinates, not by an exhaustive study. Hence, though it is reasonably certain that, in these cases, the errors are larger than the average, it is not at all certain that some errors may not exist which are larger than these.

LINE.	True Length in Meters.	Length from Co-ordinates in Meters.	Error in Meters.	Error as a Proportional Part.
Highbridge—Morris High School	2955.06	2955.05	+0.01	1-1090000
Hunter Island—Dunwoodie	8774.09	8774.10	—0.01	1-1450000
Payne—Taylor	2753.12	2753.12	0.00	1-4340000
Hollis—Far Rockaway School	13202.16	13202.18	—0.02	1-870000
Barclay—Great Kills	3329.16	3329.16	0.00	1-4340000
Sandy Hook Lighthouse—Jessup	18548.86	18548.87	—0.01	1-2170000

LINE.	True Azimuth, Reckoned Clockwise from South.			Bearing from Co-ordinates, Reckoned Clockwise from South.			Error.		Convergence of Meridians.		Difference.
	°	′	″	°	′	″	′	″	′	″	″
Highbridge—Morris High School	305	35	16.01	305	38	16.16	+3	00.15	3	59.99	0.16
Hunter Island—Dunwoodie	134	49	10.47	134	46	35.29	—2	35.18	2	35.07	0.11
Payne—Taylor	88	02	58.31	87	53	13.57	—9	44.74	9	42.60	2.14
Hollis—Far Rockaway School	354	16	05.44	354	08	11.71	—7	53.73	7	54.08	0.35
Barclay—Great Kills	250	59	36.22	251	01	39.41	+2	03.19	2	03.33	0.14
Sandy Hook Lighthouse—Jessup	121	13	26.69	121	09	00.84	—4	25.85	4	25.61	0.24

The three lines—Hunter Island-Dunwoodie, Hollis-Far Rockaway School, and Sandy Hook Light House-Jessup—are very long lines selected as being probably subject to more distortion in length than other long lines of which both ends are referred to one origin.

Three lines—Highbridge-Morris High School, Payne-Taylor, and Barclay-Great Kills—are short lines on which after examination of the routes over which the computations of co-ordinates of their end points had been carried, it was believed that the distortion in length expressed as a proportional part, and in azimuth, would probably be unusually large.

In the second of the above tables it will be noted that the difference between the bearing as computed from the co-ordinates and the true azimuth, which difference has been placed in the fourth column of the table under the heading "error," is nearly equal to the known convergence of meridians as shown in the fifth column of the table. The convergence given in the fifth column is the angle between the meridian through the origin of co-ordinates and the meridian through the station of which the name is given first in designating the line, thus, 2′ 59.99″ is the convergence of the meridians of Parkway (the origin) and of Highbridge. The small differences between corresponding values in the fourth and fifth columns are given in the last column, and serve to show that the errors in the bearings other than that due to neglect of the convergence of meridians is very small. In other words, the bearings at Highbridge are referred with a high degree of accuracy to a line through Highbridge parallel to a true south line through Parkway (the origin), but said line is at an angle of 2′ 59.99″ with the true south line at Highbridge.

The distortion which occurs in computing the rectangular linear co-ordinates depends upon the route over which the computation is carried. The following table involving the same points as are concerned in the preceding table shows in a general way the extent to which the computed co-ordinates are dependent upon the route chosen. In each case the first route specified is that used in the regular computations.

ROUTE OF COMPUTATION.

Point.	For First Route, from Origin via	For Second Route, from Origin via	Difference of X^1 Meters.	Difference of Y^1 Meters.
Highbridge...	Protectory.....	Morris High School....	.00	.01
Dunwoodie....	Straus	Hunter Island.....	.01	.03
Hollis.....	Direct	Far Rockaway School-house.....	.016	.012
Payne	College Point School-house.....	Taylor, Hollis.....	.001	.028
Great Kills....	Direct.....	Barclay, Jessup.....	.000	.002
Jessup.....	Direct.....	Sandy Hook Lighthouse	.001	.013

A change of route even within reasonable limits produces changes which are small but not inappreciable.

From the tables given it appears that the errors of approximation made in computing the rectangular linear co-ordinates are sufficiently small to be of little or no importance in connection with city surveys.

If it is ever proposed to extend these co-ordinates over a larger area it must be borne in mind that the errors of approximation in the computations increase rapidly as the area is extended.

So, too, whenever an attempt is made to carry co-ordinates from one borough into another borough in which the co-ordinates are referred to a different origin one must be cautious as to the manner in which the co-ordinates are used. To illustrate this point the following table has been prepared showing for each of eight points its co-ordinates referred to each of two origins.

Name of Station.	Origin.	X Co-ordinate Meters.	X−X_1 Meters.	Y Co-ordinate Meters.	Y−Y_1 Meters.
Bogart	Bogart	0.000		0.000	
	Prospect water tower	+12559.188	−12559.188	— 7795.604	+ 7795.604
Prospect water tower	Bogart	−12546.020		+ 7816.773	
	Prospect water tower	0.600	−12546.020	0.000	+ 7816.773
Fort Tompkins 2	Bogart	— 5044.930		+ 255.180	
	Prospect water tower	+ 7513.836	−12558.766	— 7548.933	+ 7804.113
Centennial tower	Bogart	−11913.277		— 3053.842	
	Prospect water tower	+ 651.071	−12564.348	−10869.526	+ 7815.684
Bergen Dutch Reformed Church	Bogart	— 4074.959		+13865.703	
	Prospect water tower	+ 8460.840	−12535.799	+ 6063.210	+ 7802.493
Park Row Building	Bogart	— 9124.912		+12136.078	
	Prospect water tower	+ 3413.813	−12538.725	+ 4325.067	+ 7811.011
Throg's Neck Lighthouse	Prospect water tower	−14738.862		+14722.934	
	Parkway	— 5358.13	— 9380.732	— 5871.08	+20594.014
College Point Schoolhouse	Prospect water tower	−10232.856		+12580.280	
	Parkway	— 849.42	— 9383.436	— 8008.03	+20588.310

In this table the column headed $X-X_1$ gives the difference of the X co-ordinates shown in the preceding column as referred to the two different origins. A similar statement applies to the $Y-Y_1$ column.

It may seem that values in the $X-X_1$ column should all agree for the points referred to the same two origins. As a matter of fact, for the six points referred to the origins, Bogart and Prospect Water Tower, the values of $X-X_1$ vary from —12535.799 to —12564.348, a total range of more than 28 meters. A similar variation of smaller range appears in the $Y-Y_1$ column. These variations, which arise mainly from the convergence of the meridians at the origins, which convergence is neglected in the computation of co-ordinates, must be properly taken into account when the co-ordinates of any borough are carried into another borough having co-ordinates referred to a different origin. This difficulty will not occur between the boroughs of Brooklyn and Queens, which both have their co-ordinates referred to Prospect Water Tower as an origin.

Certain Co-ordinates and Lengths Not Guaranteed.

There are certain points, namely, Richmond Hill High School dome, Fort Wadsworth Lighthouse, Metropolitan Life Building, Madison Square Garden and St. Patrick's Cathedral, for which latitudes and longitudes are furnished in the printed lists, but for which no co-ordinates are furnished. The co-ordinates are omitted because it is not intended that these points shall be used in controlling traverses as their relations to adjacent points are not known with a sufficient degree of accuracy for that purpose, or are in an inconvenient locality for that purpose. The latitudes and longitudes of these points are furnished for the convenience of persons who may desire to use them for any other purpose than the control of city surveys.

In the memorandum of the Superintendent of the Coast and Geodetic Survey, dated December 22, 1902, which is virtually a part of the agreement of co-operation, the following two statements occur which should be considered in their relation to each other. It is stated that "The distances between adjacent points determined by triangulation shall be not less than 5000 feet." It is also stated that it is proposed to take such precautions "As are necessary to insure that the maximum error in the length of any line does not exceed one part in 25000." In triangulation involving lines of various lengths in the same scheme, it is much more difficult to insure that the error of length shall be less than a given proportional part, say one part in 25000, on the shortest lines of the scheme, than on the lines of medium length. For example, it is much more difficult in the New York City triangulation to insure that the length 2604.49 feet of the very short line Copper bolt-McLean is correct within 0.10 foot (one part in 25000) than it is to insure that the length 32772.67 feet of the line Highbridge-Jackson of medium length is correct to 1.31 foot (one part in 25000). Hence the care taken to state that lines less than 5000 feet long are excluded from the agreement of co-operation and thereby to avoid guaranteeing their lengths to be correct within one

part in 25000. The precautions taken in the triangulation, and in the computations of the results, are believed to be such as to insure that the maximum error in the length of any line more than 5000 feet long does not exceed one part in 25000. Some of the evidence on which this belief is based is stated later in this report. On several of the few lines in the triangulation less than 5000 feet long the errors of length may be and probably are less than one part in 25000, but it is probable that, on some of these lines, the errors are beyond that limit. The lines less than 5000 feet long to which the limit of error one part in 25000 does not apply are:

	Feet.
Crosby-Jackson	4307
Maguire-Prospect Hill	3821
Nereid-City Line East	4653
Copper Bolt-City Line West	3192
Copper Bolt-McLean	2604
Copper Bolt-Nereid	3994
Copper Bolt-Police	4041
Armory Twenty-third Regiment-Prospect Water Tower	4459
Schoolhouse Sixtieth street-Owl Head	4025
Inebriate Asylum-Schoolhouse Seventy-ninth street	4947
Cromwell-S. I. N. E. Base	4115
Cromwell-Bogart	4458
Fox Hills-Fort Tompkins 2	4989
Stapleton Schoolhouse-Kendall	3496
Quarry Hill Schoolhouse-Summerfield Ch	4442
Bergen Point Lighthouse-Quarry Hill Schoolhouse	4401
Bergen Point Lighthouse-Summerfield Ch	4676
St. Michael's-Jessup	4967
Dupuy-Asbury Ch	4990
S. S. White-Princess Bay Lighthouse	4991
N. Hook B. L. H.-Sandy Hook Lighthouse	3912
Smith & Gray Tower-Pratt Institute	4742
Schoolhouse No. 142-Elevator	4934
Armory Thirteenth Regiment-Armory Twenty-third Regiment	4841
North Brother Island Lighthouse-Rikers Island	3463

If there are any other lines between points for which co-ordinates are given which are less than 5000 feet long it is to be understood that they are to be classed with those in the above list with the exception noted in the following paragraph.

The co-ordinates have been given for three intermediate section marks on the Ocean Parkway Base, dividing the Base into four sections, each much less than 5000 feet long. The length of each of these sections, being directly measured, is known with an error much less than one part in 25000.

Example of Figure Adjustment by Least Squares.

The least square method of making the figure adjustments is illustrated by the following example, which consists of parts of the computation of the Unionport Base figure.

All of the figure shown in the sketch was dealt with at one time in a single adjustment. The numbers printed on the lines are the numbers assigned to observed directions to identify them in the computation, thus No. 1 is the observed direction from Ludlow to Straus, No. 2 is the observed direction from Ludlow to Protectory, and No. 32 is the observed direction from Straus to Ludlow.

Throughout the example a number in a parentheses signifies the required correction to the direction having that number. Thus, (1) means the required correction to the observed direction Ludlow to Straus.

The 29 condition equations expressing the rigid conditions which must be satisfied are given below, together with the formation of the side equations and the length equations.

The first 17 condition equations are known as angle equations. Each expresses the condition that the sum of the three angles of a triangle must be equal to 180° plus the spherical excess for that triangle. Thus, condition equation No. 1 refers to the triangle Ludlow-Crosby-Protectory, and expresses the condition that the sum of the three observed angles in this triangle must be increased by 0″.32 since, as observed, the sum is 0″.32 too small. The required correction to the angle at Ludlow in this triangle is —(2) + (3), since (2) is the required correction to the direction Ludlow to Protectory and (3) is the required correction to the direction Ludlow to Crosby. Similarly, —(19) + (20) is the required correction to the angle of the triangle at Crosby, and —(24) + (27) to the angle at Protectory.

Condition equation No. 2 expresses the condition that the sum of the three observed angles of the triangle Ludlow-Castle-Protectory must be increased by 1″.88.

Condition equations Nos. 18-28, inclusive, are known as side equations. They express rigid conditions which must be satisfied to insure that if any computation of triangle sides is started from a fixed length for one line of the triangulation and carried through two different chains of triangles, arbitrarily selected, the computed lengths for all lines common to the two chains will agree.

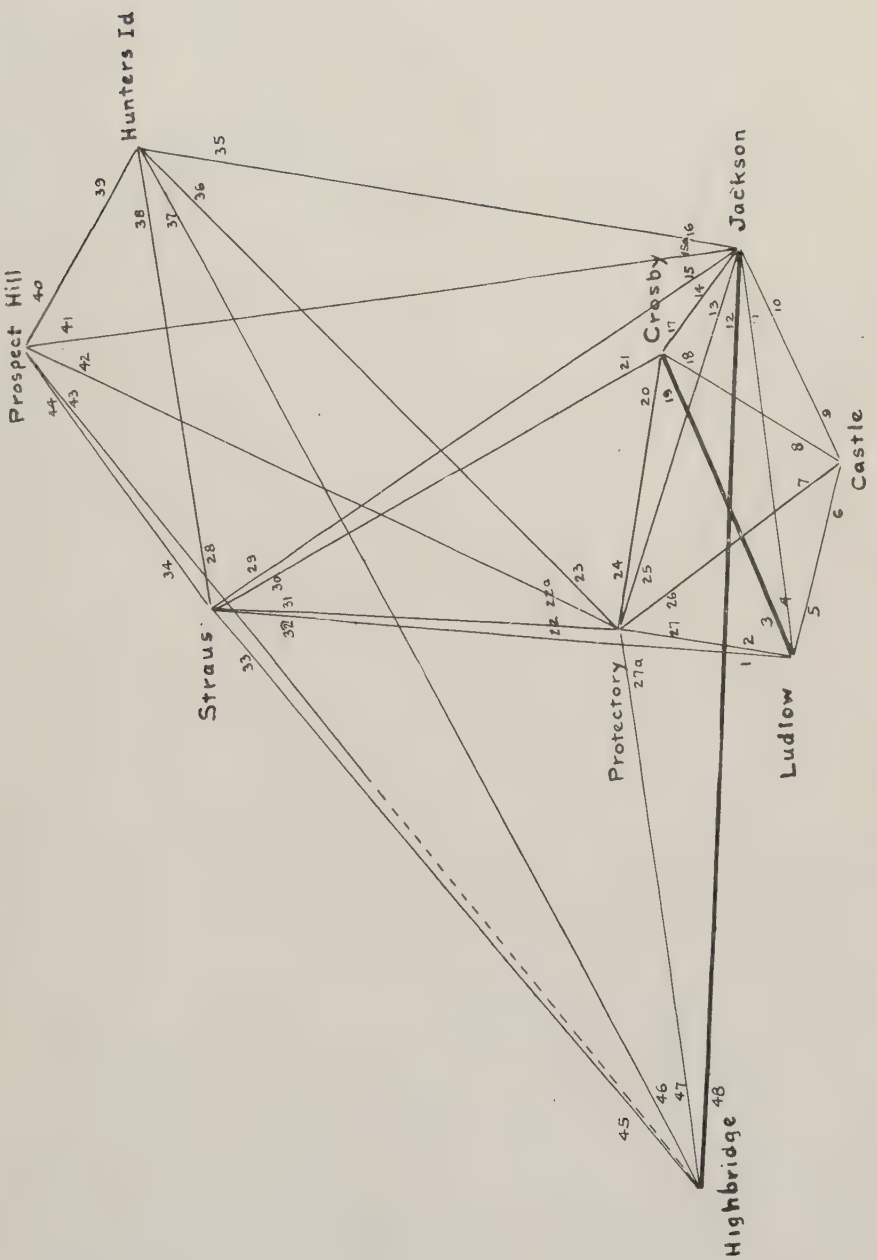
Condition equation No. 18, of which the formation is shown immediately above the equation, expresses the rigid condition that if a triangle side computation is started from the line Protectory-Hunters Island and is carried through the three triangles Protectory-Jackson-Hunters Island, Protectory-Jackson-Straus, and Protectory-Hunters Island-Straus to return to the line Protectory-Hunters Island the computed value thus obtained for the length Protectory-Hunters Island must agree with the value for that line with which the computation was started. To secure this condition it is necessary that the sum of the logarithms of the sines of the three angles, given by the differences of directions designated as —13 + 16, —36 + 38, and —29 + 31, of which angles the observed values are, respectively, 80° 16′ 17″.89, 34° 02′ 09″.41, and 39° 18′ 56″.30 shall be equal to the corresponding sums for the angles —35 + 36, — 28 + 31, and —13 + 15. The formation as given for equation 18 shows that these two sums for the observed angles differ by 94 in the seventh decimal place. In equation

18 the absolute term is, therefore, 9.4, being expressed in units of the sixth decimal place. The so-called pole of this side equation is at Protectory. For a full understanding of this equation, and of this example of least square adjustment, one must consult a good text book on least squares, or the adjustment of observations, as the full explanation is much too long to insert here.

The condition equation No. 29, known as a length equation, expresses the rigid condition that any computation of lengths in this figure which starts with the measured length of the line Crosby-Ludlow (the Unionport Base) and ends with the line Jackson-Highbridge must give a certain value for that line, this being a part of the condition that when the computation is carried through to the Ocean Parkway Base the computed length of that base shall agree with the measured length. This equation is somewhat similar to a side equation. The angles used in its formation occur in the triangles Ludlow-Straus-Crosby, Ludlow-Straus-Jackson, and Highbridge-Straus-Jackson. In order to use the spherical angles in the formation of the equation, in which the length condition should be expressed through the plane angles, it is only necessary to correct the logarithms of the lengths for the difference introduced between the two sides of the equation by the use of the logarithms of the sines instead of the logarithms of the arcs subtended at the center of the earth by these lengths. These corrections are shown over the seventh figure of the logarithms of the two lengths.

CONDITION EQUATIONS.

Number of Equation.	
1	$0 = -0.32 - (2) + (3) - (19) + (20) - (24) + (27)$
2	$0 = -1.88 - (2) + (5) - (6) + (7) - (26) + (27)$
3	$0 = +2.39 - (7) + (8) - (18) + (20) - (24) + (26)$
4	$0 = +0.34 - (4) + (5) - (6) + (9) - (10) + (11)$
5	$0 = +4.41 - (2) + (4) - (11) + (13) - (25) + (27)$
6	$0 = -2.40 - (13) + (14) - (17) + (20) - (24) + (25)$
7	$0 = -0.51 - (14) + (15) + (17) - (21) - (29) + (30)$
8	$0 = -1.73 - (20) + (21) - (22) + (24) - (30) + (31)$
9	$0 = +3.17 - (1) + (2) + (22) - (27) - (31) + (32)$
10	$0 = -1.41 - (13) + (16) - (23) + (25) - (35) + (36)$
11	$0 = -1.40 - (22) + (23) - (28) + (31) - (36) + (38)$
12	$0 = +1.36 - (28) + (33) - (37) + (38) - (45) + (46)$
13	$0 = -1.58 + (23) - (27a) - (36) + (37) - (46) + (47)$
14	$0 = +4.91 - (12) + (13) - (25) + (27a) - (47) + (48)$
15	$0 = -0.08 - (15a) + (16) - (35) + (39) - (40) + (41)$
16	$0 = -1.82 - (13) + (15a) - (22a) + (25) - (41) + (42)$
17	$0 = -1.69 - (22) + (22a) + (31) - (34) - (42) + (44)$


Prospect Hill
Hunters Id
Jackson
Crosby
Castle
Straus
Protectory
Ludlow
Highbridge
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13
14
15
16
17
18
19
20
21
22
22a
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27a
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48

Directions.	Angle. ° ′ ″	Logarithm of Sine.	Change for 1″.	Directions.	Angle. ° ′ ″	Logarithm of Sine.	Change for 1″.
—13+16	80 16 17.89	9.9937095	+0.36	—35+36	37 00 35.30	9.7795616	+2.79
—36+38	34 02 09.44	9.7479655	+3.12	—28+31	104 56 13.85	9.9850711	—0.56
—29+31	39 18 56.30	9.8018099	+2.57	—13+15	36 56 18.28	9.7788428	+2.80
		9.5434849				9.5434755	

18. $0 = +9.4+2.44\,(13) - -2.80\,(15) + 0.36\,(16) - 0.56\,(28) - 2.57\,(29) + 3.13\,(31) + 2.79\,(35) - 5.91\,(36) + 3.12\,(38)$.

—37+38	18 49 29.30	9.5087660	+6.18	— 45+46	11 05 40.00	9.2842656	+10.74
—22+23	41 01 35.36	9.8171738	+2.42	— 36+38	34 02 09.44	9.7479655	+ 3.12
—45+47	29 20 17.69	9.6901646	+3.75	—27a+22	105 31 05.29	9.9838723	— 0.58
		9.0161044				9.0161034	

19. $0 = +1.0 - 1.84\,(22) + 2.42\,(23) - -0.58\,(27a) + 3.12\,(36) - -6.18\,(37) + 3.06\,(38) + 6.99\,(45) - -10.74\,(46) + 3.75\,(47)$.

—42+43	24 12 18.39	9.6127884	+4.68	—22a+27a +42—43	28 02 34.24	9.6722195	+3.95
—13+15a	63 44 30.00	9.9526997	+1.04	—41+42	34 44 49.58	9.7558407	+3.04
—47+48	12 17 09.31	9.3279518	+9.67	—12+13	16 58 41.75	9.4653961	+6.90
		8.8934399				8.8934563	

20. $0 = -16.4+6.90\,(12) - -7.94\,(13) + 1.04\,(15a) + 3.95\,(22a) - 3.95\,(27a) + 3.04\,(41) - 11.67\,(42) + 8.63\,(43) - 9.67 + (47)\ 9.67\,(48)$.

—12+16	97 14 59.64	9.9965139	— 0.27	— 46+48	30 31 47.00	9.7058511	+3.57
+37—39)	9 47 55.46	9.2309284	+12.19	— 40+43	111 39 57.54	9.9681802	—0 84
+40—43)							
—40+41	52 42 49.57	9.9007052	+ 1.60	—15a+16	16 31 47.89	9.4541079	+7.09
		9.1281475				9.1281392	

21. $0 = +8.3+0.27\,(12)+7.09\,(15a)-7.36\,(16)+12.19\,(37)-12.19\,(39)+9.75\,(40)+1.60\,(41)-11.35\,(43)+3.57\,(46)-3.57\,(48).$

—43+44	3 05 27.49	8.7317614	+38.99	—33—44)	1 17 43.96	8.3542927	+93.10
				+34+43)			
—22+22a	22 14 02.16	9.5779386	+ 5.15	—42+44	27 17 45.88	9.6614234	+ 4.08
—45+47	29 20 17.69	9.6901646	+ 3.75	+22—27a	105 31 05.29	9.9838723	—— 0.58
		7.9998646				7.9995884	

22.* $0 = +27.62-0.46\,(22)+0.52\,(22a)-0.06\,(27a)+9.31\,(33)-9.31\,(34)+0.41\,(42)-13.21\,(43)+12.80\,(44)-0.38\,(45)+0.38\,(47).$*

—47+48	12 17 09.31	9.3279518	+9.67	—12+13	16 58 41.75	9.4653961	+6.90
—13+16	80 16 17.89	9.9937095	+0.36	—35+36	37 00 35.30	9.7795616	+2.79
—36+37	15 12 40.14	9.4189257	+7.74	—46+47	18 14 37.69	9.4956291	+6.39
		8.7405870				8.7405868	

23. $0 = +0.2+6.90\,(12)-7.26\,(13)+0.36\,(16)+2.79\,(35)-10.53\,(36)+7.74\,(37)+6.39\,(46)-16.06\,(47)+9.67\,(48).$

* This equation was formed and then divided by ten to lighten computation.

Directions.	Angle. ° ′ ″	Logarithm of Sine.	Change for 1″.	Directions.	Angle. ° ′ ″	Logarithm of Sine.	Change for 1″
—14+15	16 01 36.21	9.4423611	+ 7.31	—29+30	3 50 54.33	8.8268338	+31.30
—30+31	35 28 01.97	9.7636054	+ 2.96	—22+24	95 13 36.78	9.9981903	— 0.19
—24+25	8 31 04.05	9.1706035	+14.06	—13+14	20 51 42.07	9.5515381	+ 5.53
		8.3765700				8.3766122	

24.* 0=—4.22+0.55 (13)—1.28 (14) +0.73 (15)—0.02 (22)—1.39 (24)+1.41 (25)+3.13 (29)—3.43 (30)+0.30 (31).

—31+32	1 03 27.88	8.2662334	+114.00	— 1+ 2	2 15 45.30	8.5963691	+53.3
— 2+ 3	59 58 25.49	9.9374157	+ 1.22	—19+20	31 56 00.98	9.7234032	+ 3.38
—20+21	49 18 19.55	9.8797516	+ 1.81	—30+31	35 28 01.97	9.7636054	+ 2.96
		8.0834307				8.0833777	

25.* 0=+5.30+5.33 (1)—5.45 (2)+0.12 (3)+0.34 (19)—0.52 (20)+0.18 (21)+0.30 (30)—11.70 (31)+11.40 (32).

—13+14	20 51 42.07	9.5515881	+ 5.53	—24+25	8 31 04.05	9.1706035	+14.06
—24+27	88 05 33.23	9.9997593	+0.07	— 2+ 3	59 58 25.49	9.9374157	+ 1.22
— 3+ 4	15 04 57.12	9.4153242	+7.81	—11+14	46 13 54.71	9.8586244	+ 2.02
		8.9666716				8.9666436	

26. 0=+28.01.22 +(2) −9.03 (3)+7.81 (4)+2.02 (11)—5.53 (13)+3.51 (14)+13.99 (24)—14.06 (25)+0.07 (27).

— 4+ 5	21 57 40.48	9.5728476	+5.22	—10+11	19 07 11.57	9.5152720	+ 6.07
—10+13	44 29 24.21	9.8455851	+2.14	—25+26	34 40 48.58	9.7551083	+ 3.04
—26+27	44 53 40.60	9.8486847	+2.11	— 2+ 5	97 01 03.09	9.9867344	— 0.25
		9.2671174				9.2671147	

27. $0 = +2.7 - 0.25\,(2) - 5.22\,(4) + 5.47\,(5) + 3.93\,(10) - 6.07\,(11) + 2.14\,(13) + 3.04\,(25) - 5.15\,(26)2 + .11\,(27)$.

—26+27	44 53 40.60	9.8486847	+ 2.11	— 6+ 7	38 05 14.44	9.7901881	+ 2.69
— 6+ 8	107 44 04.67	9.9788548	—0.67	—18+19	35 13 18.57	9.7609827	+ 2.98
—19+20	31 56 00.98	9.7234032	+3.38	—24+27	88 05 33.23	9.9997593	+ 0.07
		9.5509427				9.5509301	

28. $0 = +12.6 + 3.36\,(6) - 2.69\,(7) - 0.67\,(8) + 2.98\,(18) - 6.36\,(19) + 3.38\,(20) + 0.07\,(24) - 2.11\,(26) + 2.04\,(27)$.

		0				—1	
Crosby—Ludlow.		3.5615149		Jackson—Highbridge.		3.9995275	
—19+21	81 14 20.53	9.9949031	+0.32	—30+32	36 31 29.85	9.7746432	+ 2.84
— 1+ 4	77 19 07.91	9.9892749	+0.47	—11+15	62 18 30.92	9.9471706	+ 1.11
—29+33	84 27 34.56	9.9979664	+0.20	—45+48	41 37 27.00	9.8223260	+ 2.37
		3.5436593				3.5436672	

29. $0 = -7.9 - 0.47\,(1) + 0.47\,(4) + 1.11\,(11) - 1.11\,(15) - 0.32\,(19) + 0.32\,(21) - 0.20\,(29) + 0.20\,(33) + 2.84\,(30) - 2.84\,(32) + 2.37\,(45) - 2.37\,(48)$

*This equation was formed and then divided by ten to lighten computation.

The general form of these condition equations may be expressed as follows:

$$0 = -l' + a'(1) + a''(2) + a'''(3) \ldots\ldots$$
$$0 = -l'' + b'(1) + b''(2) + b'''(3) \ldots\ldots$$
$$0 = -l''' + c'(1) + c''(2) + c'''(3) \ldots\ldots$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The absolute terms of the equations are designated in order as l', l'', l'''....., the successive coefficients of (1) (many of which are zero in the particular equations to be used) are a', b', c', etc., and of (2) are a'', b'', c'', etc.

The general form of the correlate equations which are formed from these condition equations is:

$$(1) = a'C_1 + b'C_2 + c'C_3 \ldots\ldots$$
$$(2) = a''C_1 + b''C_2 + c''C_3 \ldots\ldots$$
$$(3) = a'''C_1 + b'''C_2 + c'''C_3 \ldots\ldots$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

The actual correlate equations thus formed from the 29 condition equations for the Unionport base figure are indicated in the following tabular form in which the first line should be understood to read

$$(1) = -C_9 + 5.33C_{25} - 0.47C_{29}$$

and later lines have a corresponding meaning.

Vs	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}
(1)									−1															+ 5.33				−0.47
(2)	−1	−1			−1				+1															− 5.45	+ 1.22	−0.25			
(3)	+1																							+ 0.12	− 9.03				
(4)				−1	+1																				+ 7.81	− 5.22			+0.47
(5)		+1		+1																						+5.47			
(6)		−1		−1																							+3.36		
(7)		+1	−1																								−2.69		
(8)			+1																								−0.67		
(9)				+1																									
(10)				−1																						+3.93			
(11)				+1	−1																				+ 2.02	−6.07			+1.11
(12)													−1						+ 6.90	+ 0.27		+ 6.90							
(13)					+1	−1				−1			+1		−1		+2.44		− 7.94			− 7.26	+0.55		− 5.53	+2.14			
(14)						+1	−1																−1.28		+ 3.51				
(15)							+1										−2.80						+0.73						−1.11
(15a)														−1	+1				+ 1.04	+ 7.09									
(16)										+1				+1			+0.36			− 7.36		+ 0.36							
(17)						−1	+1																						
(18)			−1																								+2.98		
(19)	−1							−1																+ 0.34			−6.36	−0.82	
(20)	+1		+1			+1																		− 0.52			+3.38		
(21)							−1	+1																+ 0.18					+0.32
(22)								−1	+1		−1					−1		− 1.84			− 0.46		−0.02						
(22a)															−1	+1			+ 3.95		+ 0 52								
(23)										−1	+1		−1					+ 2.42											
(24)	−1		−1			−1		+1															−1.39		+13.99		+0.07		
(25)					−1	+1				+1					+1								+1.41		−14.06	+3.04			
(26)		−1	+1										−1													−5.15	−2.11		
(27)	+1	+1			+1				−1																+ 0.07	+2.11	+2.04		
(27a)												−1	+1					− 0.58	− 3.95		− 0.06								
(28)											−1	−1					−0.56												
(29)							−1										−2.57						+3.13						
(30)							+1	−1															−3.43	+ 0.80					−0.20
(31)								+1	−1		+1					+1	+3.13						+0.30	−11.70					+2.84
(32)									+1															+11.40					−2.84
(33)												+1									+ 9.31								+0.20
(34)																−1					− 9.31								
(35)										−1				−1			+2.79					+ 2.79							
(36)										+1	−1		−1				−5.91	+ 3.12				−10.53							
(37)												−1	+1					− 6.18		+12.19		+ 7.74							
(38)											+1	+1					+3.12	+ 3.06											
(39)														+1						−12.19									
(40)														−1						+ 9.75									
(41)														+1	−1				+ 3.04	+ 1.60									
(42)															+1	−1			−11.67		+ 0.41								
(43)																			+ 8.63	−11.35	−13.21								
(44)																+1					+12.80								
(45)												−1						+ 6.99			− 0.38								
(46)												+1						−10.74		+ 3.57		+ 6.39							+2.37
(47)													−1					+ 3.75	− 9.67		+ 0.38	−16.06							
(48)													+1						+ 9.67	− 3.57		+ 9.67							−2.37

There are 51 of these correlate equations, one for each required correction to a direction.

The general form of the normal equations formed from these correlate and condition equations is

$$0 = -l' + [aa]\,C_1 + [ab]\,C_2 + [ac]\,C_3 \ldots\ldots$$
$$0 = -l'' + [ab]\,C_1 + [bb]\,C_2 + [bc]\,C_3 \ldots\ldots$$
$$0 = -l''' + [ac]\,C_1 + [bc]\,C_2 + [cc]\,C_3 \ldots\ldots$$
$$\ldots\ldots$$

In this form the symbols [aa], [ab], [ac] in the first equation are to be understood as meaning the sum of such products aa, ab, ac, respectively, as would be obtained if each correlate equation in turn is multiplied through term by term by the "a" of that equation.

Similarly, the symbols, [ab], [bb], [bc], in the second equation, mean the sums of the products obtained by multiplying each correlate equation through by the "b" of that equation.

The normal equations thus formed from the correlate and condition equations for the Unionport base figure are indicated in the following tabular form.

Absolute Term.	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	Check Sum
0 = — 0.32	+6	+2	+2	0	+2	+2	0	—2	—2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 1.39	+ 4.71	— 24.17	+ 2.36	+11.71	+ 0.32	+ 6.00
0 = — 1.88		+6	—2	+2	+2	0	0	0	—2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 5.45	— 1.15	+ 12.98	— 1.90	0	+ 21.50
0 = + 2.39			+6	0	0	+2	0	—2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+ 1.39	— 0.52	— 13.99	— 5.15	+ 0.24	0	— 9.64
0 = + 0.34				+6	—2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	— 5.79	+ 0.69	— 3.36	+ 0.64	— 1.48
0 = + 4.41					+6	—2	0	0	—2	—2	0	0	0	+2	0	—2	0	+ 2.44	0	— 7.04	0	0	— 7.26	+ 0.86	+ 5.45	+ 13.17	+ 2.31	+ 2.04	— 0.64	+ 15.12
0 = — 2.40						+6	—2	—2	0	+2	0	0	0	—2	0	+2	0	— 2.44	0	+ 7.04	0	0	+ 7.26	+ 0.97	— 0.52	— 19.01	+ 0.90	+ 3 31	0	+ 2.01
0 = — 0.51							+6	—2	0	0	0	0	0	0	0	0	0	— 0.23	0	0	0	0	0	+ 4 55	+ 0.12	— 3.51	0	0	+ 1.61	— 5.07
0 = — 1.73								+6	—2	0	+2	0	0	0	0	0	+2	+ 3.13	+ 1.84	0	0	+ 0.46	0	+ 2.36	— 11.30	+ 13.99	0	— 3.31	— 2.52	+ 2.92
0 = + 3.17									+6	0	—2	0	0	0	0	0	—2	— 3.13	— 1.84	0	0	— 0.46	0	+ 0 32	+ 12.32	+ 1.15	— 2.36	— 2.04	— 2.37	— 1.88
0 = — 1.41										+6	—2	0	—2	—2	+2	+2	0	—10.78	+ 0.70	+ 7.94	— 7.36	0	— 5.70	+ 0.86	0	— 8.53	+ 0.90	0	0	— 19.38
0 = — 1.40											+6	+	+ 2	0	0	0	+2	+12.72	+ 4.20	0	0	+ 0.46	+ 10.58	+ 0.32	— 11.70	0	0	0	0	+ 25.13
0 = + 1.36												+	—2	0	0	0	0	+ 3.68	— 8.49	0	— 8.62	+ 9.69	— 1.35	0	0	0	0	0	— 2.17	+ 0.10
0 = — 1.58													+ 6	—2	0	0	0	+ 5.91	+ 8.19	— 5.72	+ 8.62	+ 0.44	— 4.18	0	0	0	0	0	0	+ 13.68
0 = + 4.91														+6	0	—2	0	+ 2.44	— 4.33	+ 0.55	— 3.84	— 0.44	+ 11.57	— 0.86	0	+ 8.53	— 0.90	0	— 2.37	+ 15.26
0 = — 0.08															+6	— 2	0	— 2.43	0	+ 2.00	— 34.79	0	— 2.43	0	0	0	0	0	0	— 31.73
0 = — 1.82																+6	—2	— 2.44	0	— 9.68	+ 5.49	— 0.11	+ 7.26	+ 0.86	0	— 8.53	+ 0.90	0	0	— 6.07
0 = — 1.69																	+6	+ 3.13	+ 1.84	+ 15.62	0	+ 22.68	0	+ 0.32	— 11.70	0	0	0	0	+ 36.20
0 = + 9.4																		+83.085	— 8.892	— 19.374	— 2.650	0	+ 52.432	— 7.807	— 36.621	— 13.493	+ 5.222	0	+ 3.622	+ 76.924
0 = + 1.0																			+245.139	— 33.972	—113.676	— 0.350	—209.540	+ 0.037	0	0	0	0	+16.566	—101.578
0 = —16.4																				+549.865	—118.372	—120.171	+354.064	+ 4.367	0	+ 43.908	— 16.992	0	—23.918	+605.981
0 = + 8.3																					+653.638	+149.934	+ 81.854	0	0	0	0	0	+ 8.461	+626.989
0 = +27.62																						+512.639	— 6.103	+ 0.009	0	0	0	0	+ 0.961	+597.259
0 = + 0.2																							+671.284	+ 3.993	0	+ 40.148	— 15.536	0	—22.918	+957.592
0 = — 4.22																								+ 28.046	— 4.539	— 46.805	+ 5.468	— 0.097	—11.178	— 47.571
0 = + 5.3																									+325.484	— 7.733	+ 1.362	— 3.920	—34.080	+237.563
0 = +28.0																										+584.415	—107.764	+ 1.122	+ 5.913	+479.871
0 = + 2.7																											+154.317	+15.171	— 9.191	+ 47.382
0 = +12.6																												+88.348	+ 2.035	+121.949
0 = — 7.9																													+30.556	— 64.171

In the general form of the normal equations as given it may be noted that the coefficients are symmetrical about a diagonal line in such a manner that each column read from the top down has in it the same coefficients in the same order as the corresponding line read from left to right. Hence, it is usual in making the computations to write only one-half of the coefficients, as has been done in the above tabular form of the normal equations, the lower left half of the table being left blank as it is known to be symmetrical with the upper right half.

In the tabular form it should therefore be understood that the fifth line indicates a normal equation which is as follows:

$$0=+4.41+2C_1+2C_2-2C_4+6C_5-2C_6-2C_9-2C_{10}+2C_{14}-2C_{16}+2.44\ C_{18}$$
$$-7.94C_{20}-7.26C_{23}-0.86C_{24}+5.45C_{25}+13.17C_{26}+2.31C_{27}+2.04C_{28}-0.64C_{29}$$

The "check sum" shown in the last column of the tabular form on each line is merely the algebraic sum of all quantities in that line, including the absolute term of the equation. This "check sum" furnishes a valuable check on the numerical work of solving the equation.

There are 29 of these normal equations containing 29 unknown quantities.

Method of Solving Normal Equations.

In solving such a heavy set of equations a special method is followed.

In order to make the process readily followed, the solution of the three normal equations,

$$[aa]\ x + [ab]\ y + [ac]\ z - [al] = 0$$
$$[ab]\ x + [bb]\ y + [bc]\ z - [bl] = 0$$
$$[ac]\ x + [bc]\ y + [cc]\ z - [cl] = 0$$

is given in general terms according to this form.

The coefficients and absolute term of the first equation are written in line 1, Table A. This first equation is divided through by the diagonal coefficient with its sign changed, and the divisors written in line 2. This gives x as an explicit function of y and x.

The coefficients and absolute term of Eq. 2 (omitting the coefficient of x) are written in line 1, Table B. The terms in line 2, Table A, beginning with that under y, are multiplied by [ab], the coefficient of y, and the products set down in line 2, Table B. The sum of lines 1, 2, Table B, is now written in line 3, Table A.

Line 4, Table A, is found from line 3 in the same way as line 2 was found from line 1. This gives y as an explicit function of z.

The coefficients and absolute term of Eq. 3 (omitting the coefficients of x and y) are written in line 3, Table B. The terms in lines 2, 4, Table A, beginning with those under z, are multiplied by [ac], [bc. 1], the coefficients of z in lines 1, 3 respectively, and the products set down in lines 4, 5, Table B. The sum of lines 3, 4, 5, Table B, is written in line 5, Table A.

Line 6, Table A, gives the value of z.

The next step is to find y and x. The coefficients of the explicit functions are written in Table C. The absolute terms of the explicit functions are written in the first line of Table D. The value of z is multiplied by the coefficients of z in Table C, and the products written in the second line of Table D. The sum of the numbers in column y gives the value of y written underneath line 3. The value of y is multiplied by the coefficients of y in Table C, and the products written in the third line of Table D. The sum of the numbers in column x gives the value of x.

A.

Recip.	x	y	z	
	+ [aa]	+ [ab]	+ [ac]	— [al]
$-\frac{1}{[aa]}$	x =	$-\frac{[ab]}{[aa]}$	$-\frac{[ac]}{[aa]}$	$+\frac{[al]}{[aa]}$
	....	[bb.1]	+ [bc.1]	— [bl.1]
$-\frac{1}{[bb.1]}$	....	y =	$-\frac{[bc.1]}{[bb.1]}$	$+\frac{[bl.1]}{[bb.1]}$
	....	....	+ [cc.2]	— [cl.2]
$-\frac{1}{[cc.2]}$	....	....	z =	$+\frac{[cl.2]}{[cc.2]}$

B.

y	z	
+ [bb]	+ [bc]	— [bl]
$-\frac{[ac]}{[aa]}[ab]$	$-\frac{[ac]}{[aa]}[ab]$	$+\frac{[al]}{[aa]}[ab]$
.....	[cc]	— [cl]
.....	$-\frac{[ac]}{[aa]}[ac]$	$+\frac{[al]}{[aa]}[ac]$
.....	$-\frac{[bc.1]}{[bb.1]}[bc.1]$	$+\frac{[bl.1]}{[bb.1]}[bc.1]$

C		D		
y	z	x	y	z
$-\frac{[ab]}{[aa]}$	$-\frac{[ac]}{[aa]}$	$+\frac{[al]}{[aa]}$	$+\frac{[bl.I]}{[bb.I]}$	$+\frac{[cl.2]}{[cc.2]}$
		$-\frac{[ac]}{[aa]}z^1$	$-\frac{[bc.I]}{[bb.I]}z^1$	z^1
		$-\frac{[ab]}{[aa]}y^1$	y^1	
.....	$-\frac{[bc.I]}{[bb.I]}$	x^1		

A sufficient portion of the actual solution of the normal equations for the Unionport Base figure is reproduced below to serve as a concrete illustration and to enable one to follow enough of the numerical work to make certain of his understanding of it.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	SOLUTION	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	Absolute Term.	Check Sum.
	+6.0	+2.0	+2.0		+2.0	+2.0		2.0	−2.0		+1.39	+4.71	−24.17	+ 2.36	+ 11.71	+ 0.32	−0.32	+ 6.00
1	−1.0	−0.333333	−0.333333		−0.333333	−0.333333		0.333333	+ 0.333333		−0.231667	−0.785000	+ 4.028333	− 0.393333	− 1.951667	−0.053333	+ 0.053333	− 1.000000
	+2.0	+6.0	−2.0	+ 2.0	+ 2.0				−2.0			+ 5.45	− 1.150	+ 12.980	− 1.900		−1.880	+ 21.500
	−2.0	−0.667	− 0.667		−0.667	−0.667		0.667	+ 0.667		−0.463	−1.57	+ 8.057	− 0.787	− 3.903	−0.107	+ 0.107	− 2.000
	0	+ 5.333	−2.667	+ 2.0	+ 1.333	−0.667		0.667	−1.333		−0.463	+ 3.88	+ 6.907	+ 12.193	− 5.803	−0.107	−1.773	+ 19.500
	0	2 −1.0	+ 0.500000	−0.375000	−0 250000	+ 0.125000		0.125000	+ 0.250000		+ 0.086812	−0.727500	− 1.295662	− 2.286188	+ 1.088062	+ 0.020062	+ 0.332438	3.656250
	+2.0	−2.0	+ 6.0			+ 2.000		2.0			+ 1.390	−0.520	−13.990	− 5.150	+ 0.240		+ 2.390	− 9.640
	−2.0	− .667	−0.667		−0.667	−0.667		0.667	+ 0.667		−0.463	−1.570	+ 8.057	− 0.787	− 3.903	−0.107	+ 0.107	− 2.000
	0	+2.667	−1.333	+ 1.000	+ 0.667	−0.333		0.333	−0.667		−0.231	+ 1.940	+ 3.453	+ 6.097	− 2.901	−0.053	−0.887	+ 9.750
	0	0	+ 4.000	+ 1.000		+ 1.000		1.000			+ 0.696	−0.150	− 2.480	+ 0.160	− 6.564	−0.160	+ 1.610	− 1.890
	0	0 3	−1.0	−0.250000		−0.250000		0.250000			−0.174000	+ 0.037500	+ 0.620000	− 0.040000	+ 1.641000	+ 0.040000	−0.402500	+ 0.472500
	0	+2.0	0	+ 6.0	−2.0								− 5.790	+ 0.690	− 3.860	+ 0.640	+ 0.340	− 1.480
	0	−2.0	+1.0	−0.750	−0.500	+ 0.250		0.250	+ 0.500		+ 0.174	−1.455	− 2.590	− 4.572	+ 2.176	+ 0.040	+ 0.665	− 7.313
	0	0	−1.0	−0.250		−0.250		0.250			−0.174	+ 0.038	+ 0.620	− 0.040	+ 1.641	+ 0.040	−0.402	+ 0.472
	0	0	0	+ 5.000	−2.500				+ 0.500			−1.417	− 7.760	− 3.922	+ 0.457	+ 0.720	+ 0.603	− 8.321
	0	0	0 4	−1.0	+ 0.500000				−0.100000			+ 0.283400	+ 1.552000	+ 0.784400	− 0.091400	−0.144000	−0.120600	+ 1.663800
				5		★		★	★	★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
					6		★	★		★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
						7		★		★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
							8		★	★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
								9		★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
								10		★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
									11	★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
									12	★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
									13	★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★
									14	★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★	★	★	★	★	★	★	★	★

SOLUTION—*Continued.*

C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	Absolute Term	Check Sum
	★	★	★	☆	★	★	★	★	★	★	★	★	★	★	★	★
16		★	★	★	★	★	★	★	★	★	★	★	★	★	★	★
	17		★	★	★	☆	★	★	★	★	★	★	★	★	★	★
		18		★	★	★	★	★	★	★	★	★	★	★	★	★
			19		★	★	★	★	★	★	★	★	★	★	★	★
				20		★	★	★	★	★	★	★	★	★	★	★
					21		★	★	★	★	★	★	★	★	★	★
						22		★	★	★	★	★	★	★	★	★
							23		★	★	★	★	★	★	★	★
								24			★	★	★	★	★	★
									25		★	★	★	★	★	★
										26		★	★	★	★	★
											27		★	★	★	★

C_{22}
23

SOLUTION—*Continued.*	C_{28}	C_{29}	Absolute Term.	Check Sum.
	+88.348	+2.035	+12.6	+121.949
	—22.854	—0.625	+ 0.625	— 11.710
	— 6.314	—0.116	— 1.929	+ 21.217
	—10.772	—0.263	+ 2.642	— 3.098
	— 0.042	—0.066	— 0.055	+ 0.760
	— 0.009	—0.018	+ 0.258	+ 0.201
	— 0.012	+0.019	— 0.035	— 0.339
	— 0.003	—0.035	+ 0.004	+ 0.042
	— 0.005	—0.096	— 0.103	+ 0.096
	— 0.012	+0.222	— 0.145	— 0.481
	— 0.003	+0.001	+ 0.039	— 0.455
	— 0.002	—0.006	— 0.024	— 0.430
	— 0.001	—0.025	+ 0.009	— 0.097
	— 0.003	—0.036	— 0.021	— 0.105
	— 0.000	+0.034	— 0.018	— 0.100
	— 0.000	—0.001	+ 0.005	+ 0.130
	— 0.002	—0.003	+ 0.016	— 0.353
	— 0.001	+0.005	— 0.005	— 0.420
	— 0.000	+0.001	+ 0.003	+ 0.003
	— 0.000	—0.002	— 0.001	+ 0.021
	— 0.002	—0.041	— 0.004	+ 1.074
	— 0.000	+0.010	+ 0.027	+ 0.754
	— 0.001	—0.001	+ 0.021	+ 0.585
	— 0.000	—0.001	- 0.002	+ 0.038
	— 0.211	—0.933	— 0.088	— 3.566
	— 0.446	—1.256	— 0.202	+ 6.704
	— 8.277	+1.070	— 1.961	— 42.142
	—17.706	+4.318	— 6.393	— 59.162
	+21.670	+4.191	+ 5.263	+ 31.116
28		—0.1934	— 0.2429	— 1.4363

SOLUTION—*Continued.*	C_{29}	Absolute Term.	Check Sum.
	+30.556	—7.9	-47.571
	— 0.017	+0.017	— 0.320
	— 0.032	—0.036	+ 0.391
	— 0.006	+0.064	— 0.076
	— 0.102	—0.087	+ 1.198
	— 0.035	+0.505	+ 0.392
	— 0.031	+0.057	+ 0.542
	— 0.419	+0.046	+ 0.497
	— 0.848	—0.910	+ 0.851
	— 4.048	+2.657	+ 8.784
	— 0.000	—0.015	+ 0.178
	— 0.016	—0.063	— 1.122
	— 1.089	+0.396	— 4.314
	— 0.448	—0.255	— 1.298
	— 3.365	+1.735	+ 9.769
	— 0.013	+0.058	+ 1.587
	— 0.006	+0.029	— 0.665
	— 0.022	+0.020	+ 1.804
	— 0.257	—0.714	— 0.718
	— 0.547	—0.415	+ 6.753
	— 0.786	—0.085	+20.679
	— 0.193	—0.530	—15.059
	— 0.001	+0.025	+ 0.704
	— 0.094	—0.126	+ 2.952
	— 4.132	—0.385	—15.794
	— 3.533	—0.568	+18.859
	— 0.138	+0.253	+ 5.445
	— 1 053	+1.559	+14.422
	— 0.811	—1.018	— 6.019
	+ 8.544	*—5.686	+ 2.851
29		+0.6671	— 0.3329

* By inadvertence 5.7 was used in the original solution, instead of 5.686. If this mistake were corrected the value of C_{29} would be changed from +0.″6671 to +0.″6655, and other very small changes of no importance would be made in the values of other C's.

BACK SOLUTION.

C_{29}	C_{28}	C_{27}	C_{26}	C_{25}	C_{24}	C_{23}	C_{22}	C_{21}	C_{20}	C_{19}	C_{18}	C_{17}	C_{16}	C_{15}	C_{14}	C_{13}	C_{12}
+0.6671	−0.2429	−0.1623	−0.04101	+0.01963	+0.04233	+0.06814	−0.07797	−0.08313	+0.00454	−0.03881	−0.20304	−0.07582	−0.20175	+0.23974	−0.53804	+0.20289	−0.17158
	−0.1290	+0.0731	+0.01492	+0.08149	+0.30314	★	★	★	★	★	★	★	★	★	★	★	★
		+0.1672	+0.06436	−0.01615	−0.03816	★	★	★	★	★	★	★	★	★	★	★	★
	−0.3719		+0.02423	+0.00119	−0.02078	★	★	★	★	★	★	★	★	★	★	★	★
		+0.0780		+0.00922	+0.12876	★	★	★	★	★	★	★	★	★	★	★	★
			+0.06250		+0.03280	★	★	★	★	★	★	★	★	★	★	★	★
				+0.09538		★	★	★	★	★	★	★	★	★	★	★	★
					+0.44809		★	★	★	★	★	★	★	★	★	★	★
						+0.02463		★	★	★	★	★	★	★	★	★	★
							−0.12824		★	★	★	★	★	★	★	★	★
								+0.00416		★	★	★	★	★	★		
									−0.03114		★	★	★	★	★	★	★
										−0.02723		★	★	★	★	★	★
											−0.15490		★	★	★	★	★
												+1.0553		★	★	★	
													+0.2481		★	★	★
														+0.38026		★	
															+0.2979		★
																+0.8830	
																	+0.9198

BACK SOLUTION

C_{22}	C_{21}	C_{20}
.07797	−0.08313	+0.004
★	★	★
★	★	★
★	★	★
★	★	★
★	★	★
★	★	★
★	★	★
	★	★
.12824		★
	+0.00416	
		−0.031

BACK SOLUTION—*Continued.*

C_{11}	C_{10}	C_9	C_8	C_7	C_6	C_5	C_4	C_3	C_2	C_1
−0.26123	−0.34350	−0.7381	+.520834	+0.032292	−.177300	−1.403200	−.120600	−.402500	+.332438	+.053333
★	★	★	★	★	★	★	★	+.026684	+.013383	−.035578
★	★	★	★	★	★	★	★	−.610288	−.404650	+.725825
★	★	★	★	★	★	★	★	−.003120	−.178823	−.030680
★	★	★	★	★	★	★	★	+.038750	−.080941	+.251770
★	★	★	★	★	★	★	★	+.003577	−.069389	−.074873
★	★	★	★	★	★	★		−.077968	+.38900	−.103808
★	★		★	★	★	★				
★	★	★	★							
★	★									
	★		★	★	★	★				
★	★	★	★							
★	★	★	★	★	★	★				
★	★	★	★							
	★		★	★	★	★				
★	★									
	★		★	★	★	★				
★	★									
★										
−1.0078	★	★	★							
	−0.9085		★	★	★	★				
		−0.3126	★			★	★		−.07815	−.10420
			+1.0724	★	★	★		+.26810	−.13405	+.35747
				+0.9389	★					
					+0.9210	★		−.23025	+.11512	−.30700
						−1.4771	★		+.36928	+.49237
							−0.7047	+.17618	+.26426	
								−0.8108	−.40540	+.27027
									−0.2175	+.07250
										+1.5674

	C_4	C_3	C_2	C_1
.0779	—.120600	—.402500	+ .332438	+ .053333
★	★	+ .026684	+ .013383	—.035578
★	★	—.610288	—.404650	+ .725825
★	★	—.003120	—.178323	—.030680
★	★	+ .038750	—.080941	+ .251770
★	★	+ .003577	—.069389	—.074873
★		—.077968	+ .38900	—.103808
★				
★				
.1282				
	★		—.07815	—.10420
		+ .26810	—.13405	+ .35747
		—.23025	+ .11512	—.30700
	★		+ .36928	+ .49237
	—0.7047	+ .17618	+ .26426	
		—0.8108	—.40540	+ .27027
			—0.2175	+ .07250
				+1.5674

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}	C_{29}	Corrections to Directions V.
(1)									+0.333															+0.508				−0.314	+0.507
(2)	−1.567	+0.218			+1.477				−0.333															−0.520	+0.076	−0.020			−0.649
(3)	+1.567			+0.705	−1.477																			−0.011	−0.564				+1.614
(4)																									+0.488	−0.407		+0.314	−0.377
(5)		−0.218		−0.705																						+0.427			−0.496
(6)		+0.218		+0.705																							1.250		+0.327
(7)		−0.218	+0.811																								+1.000		+1.592
(8)			−0.811																								+0.249		−0.562
(9)				−0.795																									−0.705
(10)				+0.705																						+0.307			+1.012
(11)				−0.705	+1.477																				+0.126	−0.474		+0.740	+1.164
(12)														−0.298						−0.215	+0.001		+0.170						−0.342
(13)					−1.477	−0.921				+0.908				+0.298		−0.248			−0.378	+0.247			−0.179	+0.246					−1.683
(14)						+0.921	−0.939																	−0.574	−0.346	+0.167			−0.373
(15)							+0.939												+0.434					+0.327	+0.219				+0.960
(15a)																	−0.380	+0.248										−0.740	−0.135
(16)										−0.908							+0.380		−0.056	−0.032	+0.029								−0.606
(17)						−0.921	+0.939														−0.031		+0.009							+0.018
(18)			+0.811																								−1.108		−0.297
(19)	−1.567							−1.072																+0.032			+2.365	−0.213	+0.617
(20)	+1.567		−0.811			+0.921	−0.939	+1.072																+0.050			−1.357		−0.702
(21)								−1.072	−0.333		+1.008				−1.055		+0.050					+0.059		+0.017				−0.308
(22)																−0.248				−0.123			−0.009					−0.213	−1.332
(22a)										+0.908	−1.008		+0.883		+1.055							−0.067							−0.617
(23)	−1.567		+0.811			−0.921		+1.072									−0.066							−0.623		+0.874		−0.026	−0.717
(24)					+1.477	+0.921				−0.908				−0.298		+0.248								+0.632		−0.879	+0.237		−0.380
(25)		+0.218	−0.811						+0.333																		−0.402	+0.785	−1.430
(26)					−1.477																					+0.004	+0.165	−0.759	−0.210
(27)	+1.567	−0.218											−0.883	+0.298															−0.405
(27a)											+1.008	−0.920							+0.087	+0.016	+0.123		+0.008						−0.438
(28)							−0.939												+0.398										−0.175
(29)							+0.939	−1.072																				−0.133	+0.728
(30)								+1.072	+0.333		−1.008				+1.055				−0.485				+1.402	−1.537	+0.029			+1.895	+0.254
(31)									−0.333														+0.134	+0.134	−1.116				−0.035
(32)												+0.920													+1.087			−1.895	−1.121
(33)															−1.055							−1.194						+0.133	−0.141
(34)										+0.908									−0.432			+1.194							+0.139
(35)										−0.908	+1.008		−0.883			−0.380			+0.915	−0.085			+0.069						+0.165
(36)												−0.920	+0.883							+0.168			−0.260						−0.213
(37)											−1.008	+0.920							−0.483	−0.083	+0.051		+0.191						+0.373
(38)																+0.380					−0.051								−0.654
(39)																−0.380					+0.041								+0.329
(40)																+0.380	−0.248			−0.095	+0.007								−0.339
(41)																	+0.248	−1.055			+0.363		−0.053							+0.044
(42)																				−0.269	−0.047	+1.694								−0.497
(43)																		+1.055				−1.642								+1.378
(44)												−0.920										+0.049								−0.587
(45)												+0.920	−0.883						−0.190		+0.015		+0.158						+1.581	+0.520
(46)													+0.883	−0.298					+0.292	+0.301		−0.049	−0.396							−0.502
(47)														+0.298					−0.102	−0.301	−0.015		+0.238							+0.339
(48)																													−1.581	−1.361

SUBSTITUTION IN CORRELATE EQUATIONS TO OBTAIN CORRECTIONS T

C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}
0.33									
0.33									

Explanation of Example of Solution.

The numerical solution shown above for the Unionport Base figure consists of a combination of tables A and B. The arrangement of the numerical work shown is that which has been found to be most convenient.

The symbol at the top of each column denotes the unknown whose coefficients appear in that column.

The first line in the solution consists of the coefficients, and the absolute term, of the first normal equation written in the proper columns. It corresponds to the first line in Table A. The second line in the solution is obtained from the first by dividing each coefficient by minus the coefficient of C_1, that is, by -6.0. This gives -1 as the coefficient of C_1. This corresponds to the second line in Table A.

The coefficients and absolute term of the second normal equation are written in line 3 of the solution, as in line 1 of Table B. Line 4 of the solution is obtained in the same manner as line 2 of Table B, that is, by multiplying each term in line 2 of the solution by $+2.0$ (the coefficient of C_2 in the first normal equation) and writing the products in the proper columns. The addition of lines 3 and 4 of the solution gives line 5 which corresponds to line 3 of Table A. This line 5 is an equation with C_1 eliminated. Dividing this line by minus the coefficient of C_2 (-5.333) gives the next line in the solution, which corresponds to line 4 of Table A.

The seventh line of the solution is obtained by writing the coefficients, and absolute term, of the third normal equations in the proper columns, as line 3, Table B, is obtained. Next, each term in line 2 of the solution is multiplied by $+2.0$, the coefficient of C_3 in the first normal equation and the products are written in the proper columns in line 8. Each term in line 6 is multiplied by -2.667, the coefficient of C_3 in line 5, and the products are written in line 9. This multiplier (-2.667) is used instead of -2.0, the coefficient of C_3 in the second normal equation because line 6 is obtained from line 5 in the same manner as line 2 is obtained from line 1 (or the first normal equation). Lines 8 and 9 of the solution correspond to lines 4 and 5 in Table B. Lines 7, 8 and 9 in the solution are added and the sums written in line 10. Line 10 is an equation with C_1 and C_2 eliminated. Compare this with line 5 of Table A. Line 11 of the solution, which corresponds to line 6 of Table A, is obtained by dividing each term in line 10 by minus the coefficient of C_3 in that line (-4.000).

Next the coefficients and absolute term of the fourth normal equation are written in the twelfth line and the solution is carried forward as before.

The coefficients which appear in italics at the left hand end of the first 16 lines in the solution are printed merely to show how the elimination of the unknowns actually takes place. These coefficients are not ordinarily written in the solution since it is known in advance that in each column they become zero at a certain stage of the solution.

When a normal equation is written in the solution, as on lines 1, 3, 7, etc., the check sum is written in the column having that heading.

In the various steps of the solution this check sum is put through the same operations as the absolute terms. After each addition of two or more lines, which gives an equation with one or more unknowns, (C's) eliminated, for example, lines 5, 10, etc., the check sum in that line should be the algebraic sum of all the other terms in that line. Any discrepancy greater than may arise from the effects of omitted decimal places indicates an error in the solution. Similarly, the check sum in each line of quotients, such as lines 2, 6, 11, etc., should be the algebraic sum of all the other terms in that line including the—1 which is not written in the actual solution.

Table C is a copy of a part of Table A and is not used separately in the ordinary computation.

The middle portion of the solution has not been printed. It is merely indicated in skeleton outline by stars as explained in the note printed with the solution. The amount of computing involved in this solution may be inferred from the fact that there are 379 lines in the whole solution as made.

The last few steps of the solution, involving C_{28} and C_{29} only, are shown.

At the end of the solution after dividing by the coefficient of C_{29} an equation is obtained (in the line of the solution marked with the bold faced number 29) which involves only C_{29} and the absolute term. Since — 1 (understood, but not written) is the coefficient of C_{29}, the value of C_{29} is the absolute term + 0.6671.

The equation in the solution marked with the bold-faced number 28 involves only C_{28}, C_{29}, and the absolute term. The value of C_{29}, + 0.6671 being multiplied by its coefficient — 0.1934 in this equation and the product added algebraically to the absolute term — 0.2429 gives the value of C_{28}. In other words, the value of C_{29}, now known, is substituted is this equation to obtain C_{28}.

Similarly, the value of C_{27} is obtained by substituting the values of C_{28}, and C_{29}, in the equation marked 27 in bold-faced numbers, and so on for all the other unknowns.

This work of substitution is performed most advantageously in a table shown above as the "back solution," and which corresponds to Table D. In each column of the back solution is shown the substitution to obtain the value of the unknown indicated at the head of the column. The first value in each column is the absolute term of the equation in which the substitution was made, and the algebraic sum at the bottom of the column is the required value of the unknown.

(The order in which the numerical work of the back solution may be done most efficiently is that shown in the next paragraph.)

Take each absolute term of the solution which stands in a line marked with a bold-faced number and write it in the first line of the back solution in the column headed with a "C," having that number for a subscript. The absolute term in the C_{29} column of the back solution + 0.6671 is the value of C_{29}, as already stated. Multiply this value by each coefficient in the C_{29} column of the solution in the lines marked with bold-faced numbers and write the products in line 2 of the back solution in the proper columns as explained above for the absolute term.

Add the values in the C_{28} column of the back solution to secure the value of C_{28}, as shown at the bottom of the column. Multiply each coefficient in the C_{28} column of the solution in the lines marked with bold-faced numbers by the value of C_{28} and write the products in line 3 of the back solution. Add the values in the C_{27} column of the back solution to obtain the value of C_{27} as shown at the bottom of the column. Proceed in this manner until all the unknowns have been obtained.

This back solution corresponds to table D. The lines marked with bold-faced numbers in the solution are used without copying them into a separate table, such as Table C. It is to be noted, also, that it has been found convenient in the computation to make the order of the columns in the back solution the reverse of that shown in Table D.

Multiplying machines were used in making the solution and back solution and served to make the computations much more rapid that they otherwise would be.

Statistics of Figure Adjustments.

In the computation of the Greater New York triangulation 99 figure adjustments were made such as that for the Unionport Base figure. The following tabular statement taken in connection with the published triangulation sketches show the principal facts in regard to these adjustments.

Old Points Involved.	New Points Determined.	Number Angle Equations.	Number Side Equations.	Number Observed Directions.
	Ocean Parkway North base, Ocean Parkway South base, Avenue K schoolhouse, Far Rockaway schoolhouse, Prospect water tower, Hollis, Centennial Tower, Fort Tompkins 2, Seaside Hotel,	17	11	50
Fort Tompkins 2, Centennial Tower, Prospect water tower..	Park Row Building, Bergen Dutch Reformed Church, Bogart *.....	6	4	20
Park Row Building, Hollis, Prospect water tower, Centennial Tower.....	Lutheran Cemetery Church, Memorial Church, Highwood 2.....	7	5	21
Memorial Church, Highwood 2, Prospect water tower, Lutheran Cemetery Church, Hollis, Park Row Building	Highbridge, Jackson, College Point schoolhouse **.....	8	8	24
Highbridge, Jackson.....	Ludlow, Crosby, Castle, Protectory, Straus, Hunter Island, Prospect Hill.....	17	12	51
Straus, Prospect Hill, Hunter Island, Jackson, Highbridge....	City Line West.....	4	3	10
Prospect Hill, Straus, Hunter Island, Jackson, Highbridge....	Dunwoodie.....	3	3	10
Straus, Hunter Island, Jackson, Crosby, Ludlow, Protectory...	Parkway.....	5	4	12
Jackson, Crosby, Protectory, Parkway, Straus, Hunter Island, Prospect Hill.....	City Island, Pilot, Hart Island.....	9	8	26

* Bergen Dutch Reformed Church, Park Row readjusted. ** College Point schoolhouse readjusted later.

Parkway, Straus, Prospect Hill, Hunter Island	Baychester, Maguire	7	5	18
City Line West, Prospect Hill, Hunter Island, Straus	City Line East	3	2	8
Dunwoodie, Prospect Hill, City Line West, Straus, Parkway, Protectory, Highbridge	Jerome water tower	3	5	11
Dunwoodie, Prospect Hill, Straus, Jerome water tower, Highbridge	McLean	3	3	9
City Line East, Straus, McLean, City Line West, Jerome water tower	Briggs, Police	5	5	16
McLean, Prospect Hill, City Line West, City Line East, Maguire, Straus, Police	Nereid	6	5	14
McLean, Nereid, Police, City Line West	Copper Bolt	0	2	3
Jerome water tower, Straus, Parkway, Protectory, Jackson, Ludlow, College Point schoolhouse, Highbridge	Morris High School *	5	6	14
Straus, Parkway, Ludlow, Protectory, Morris High School	West Farms school	0	3	5
Pilot, Jackson, Castle	Throgs Neck lighthouse (old)	2	1	6
Ludlow, College Point schoolhouse, Morris High School	Rikers Island **	1	1	5
Parkway, Castle, Ludlow	Westchester courthouse	0	1	2
Lutheran Cemetery Church, Prospect water tower, Avenue K schoolhouse, Centennial Tower, Seaside Hotel, Far Rockaway schoolhouse	Ridgewood gatehouse	0	4	6
Fort Tompkins 2, Avenue K schoolhouse, Ocean Parkway South base, Ocean Parkway North base, Centennial Tower	Bensonhurst schoolhouse	4	3	10
Bogart, Fort Tompkins 2, Bensonhurst schoolhouse, Ocean Parkway South base, Centennial Tower	Coney Island lighthouse	4	3	10
Fort Tompkins 2, Coney Island lighthouse, Bensonhurst schoolhouse, Ocean Parkway South base, Centennial Tower	Fort Hamilton flagstaff	3	3	9
Prospect water tower, Ocean Parkway North base, Ocean Parkway South base, Centennial Tower, Bensonhurst schoolhouse, Fort Hamilton flagstaff, Avenue K schoolhouse	Schoolhouse Forty-fourth street, Schoolhouse Seventy-ninth street, Avenue C schoolhouse	11	8	28

* Readjusted later. ** Readjusted.

Old Points Involved.	New Points Determined.	Number Angle Equations.	Number Side Equations.	Number Observed Directions.
Prospect water tower, Schoolhouse Forty-fourth Street, Avenue C schoolhouse, Avenue K schoolhouse, Ocean Parkway North base	Kings County Asylum	3	3	9
Prospect water tower, Ridgewood gatehouse, Avenue K schoolhouse, Ocean Park South base, Centennial Tower, Seaside Hotel	Canarsie Park	2	4	9
Prospect water tower, Canarsie Park, Avenue K schoolhouse, Ocean Parkway North base, Ocean Parkway South base, Centennial Tower, Seaside Hotel	Avenue U, Barren Island schoolhouse	9	8	23
Canarsie Park, Avenue U, Seaside Hotel, Barren Island schoolhouse	Duck Point, Ruffle Bar 3	5	5	16
Canarsie Park, Avenue U, Ocean Parkway South base, Centennial Tower, Barren Island schoolhouse	Point Breeze 3, Rockaway Point	6	6	18
Prospect water tower, Canarsie Park, Duck Point, Ruffle Bar 3, Seaside Hotel, Avenue U, Centennial Tower	Bergen Beach Casino	0	5	7
Canarsie Park, Duck Point, Avenue U, Ruffle Bar 3, Barren Island schoolhouse	Island Channel	0	3	5
Canarsie Park, Ruffle Bar 3, Avenue U, Barren Island schoolhouse	Mill Island	0	2	4
Avenue U, Canarsie Park, Ruffle Bar 3, Barren Island schoolhouse, Rockaway Point, Point Breeze 3	Riches Point	0	4	6
Canarsie Park, Duck Point, Ruffle Bar 3, Avenue U, Barren Island schoolhouse	Canarsie Pol	0	3	5
Canarsie Park, Avenue U, Ruffle Bar 3, Seaside Hotel, Barren Island schoolhouse, Rockaway Point	Rockaway Point Life Saving Station	0	4	6
Lutheran Cemetery Church, Ridgewood Gatehouse, Prospect water tower, Canarsie Park, Avenue K schoolhouse, Avenue C schoolhouse, Kings County Asylum	Church Northeast tower, Blake Avenue schoolhouse, Rugby tower	9	8	26
Highwood 2, Memorial Church, College Point schoolhouse, Lutheran Cemetery Church, Prospect water tower, Fort Tompkins 2	Park Row Building	4	4	11
Park Row Building, Prospect water tower, Fort Tompkins 2, Centennial Tower	Bogart, Summerfield Church, Jesup, Great Kills, Sandy Hook lighthouse	14	9	38

Park Row Building, Prospect water tower, Fort Tompkins 2, Bogart	3	2	8
Summerfield Church, Fort Tompkins 2, Bogart, Great Kills, Jessup	11	7	30
Bergen Dutch Reformed Church, Park Row Building, Prospect water tower, Summerfield Church, Bogart, Fort Tompkins 2, Fort Hamilton flag staff	4	9	18
Bogart, Wyeth, Elm Tree, Great Kills	6	4	16
Bogart, Wyeth, Elm Tree, Staten Island Northeast base, Fort Tompkins 2	4	3	10
Summerfield Church, Kendall, Bogart, Linoleumville schoolhouse	5	4	15
Bogart, Fort Tompkins 2, New Creek, Elm Tree, Staten Island Northeast base	6	4	16
Kendall, St. George schoolhouse, Kolff, Fort Tompkins 2, Cromwell, Elm Tree	5	4	15
Summerfield Church, St. George schoolhouse, Kendall, Bogart, Quarry Hill schoolhouse, Linoleumville schoolhouse	6	6	18
Summerfield Church, Quarry Hill schoolhouse, West Brighton schoolhouse, St. George schoolhouse, Bogart	2	4	11
Summerfield Church, Westerleigh schoolhouse, Bogart, Linoleoumville schoolhouse	6	4	16
Rossville Jessup, Great Kills, Elm Tree	10	7	29
Rossville, Jessup, Sharrot, Tottenville schoolhouse, Princess Bay lighthouse	4	3	10
Wyeth, Great Kills, Jessup, Rossville, Linoleumville schoolhouse	5	5	16
Jessup, Great Kills, Barclay, Sharrot, Princess Bay lighthouse	4	3	10
Rossville, Jessup, Sharrot, Kreusler, Tottenville schoolhouse, Princess Bay lighthouse	1	6	14
Summerfield Church, Quarry Hill schoolhouse, Westerleigh schoolhouse, Bogart, Linoleumville schoolhouse, Bloomfield church	8	7	24
Jessup, Barclay, Sharrot, Princess Bay lighthouse	2	2	7

Bergen Dutch Reformed Church	3	2	8
Elm Tree, Wyeth, Linoleumville schoolhouse, Rossville	11	7	30
St. George schoolhouse, Kendall	4	9	18
Staten Island Northeast base, Staten Island Southwest base	6	4	16
New Creek	4	3	10
Quarry Hill schoolhouse, Westerleigh schoolhouse	5	4	15
Cromwell, Kolff	6	4	16
Fox Hills, Stapleton schoolhouse	5	4	15
Bard, West Brighton schoolhouse	6	6	18
Snug Harbor Church, Bergen Point lighthouse	2	4	11
Bloomfield Church, Old Place	6	4	16
Barclay, Sharrot, Tottenville schoolhouse, Princess Bay lighthouse.	10	7	29
Kreusler	4	3	10
Gifford, St. Michaels	5	5	16
S. S. White	4	3	10
Boundary Beacon, Great Beds lighthouse, St. Peters Church	1	6	14
Lambert, Asbury Church, Dupuy	8	7	24
Huguenot Church	2	2	7

Old Points Involved.	New Points Determined.	Number Angle Equations.	Number Side Equations.	Number Observed Directions.
Wyeth, Bogart, Fort Tompkins 2, Elm Tree, Great Kills, Barclay	Old Orchard lighthouse	0	4	6
Bogart, Jessup, Kreusler	Woodbridge spire	3	2	8
Summerfield Church, Old Place, Bogart, Linoleumville schoolhouse	Stephenson clock tower	0	2	4
Fort Tompkins 2, Bogart, Elm Tree, Great Kills, Sandy Hook lighthouse	North Hook Beacon lighthouse	0	3	5
Park Row Building, Lutheran Cemetery Church, Prospect water tower, Ridgewood gatehouse, Church Northeast tower, Blake avenue schoolhouse, Kings County Asylum	Eppig brewery, Pratt Institute, 23d Regiment Armory	7	6	22
Bergen Dutch Reformed Church, Park Row Building, Prospect water tower, St. George schoolhouse, Kendall, Fort Tompkins 2, Schoolhouse Seventy-ninth street, Schoolhouse Forty-fourth street	Elevator, Statue of Liberty, Owl Head	5	10	23
Bergen Dutch Reformed Church, Park Row Building, Pratt Institute, Prospect water tower, Fort Tompkins 2, 23d Regiment Armory, Elevator	Schoolhouse No. 142, Standish Arms, Smith & Gray tower	10	10	29
Pratt Institute, Eppig brewery, Church Northeast tower, Blake avenue schoolhouse, Kings County Asylum, 23d Regiment Armory	13th Regiment Armory	5	4	12
Park Row Building, Prospect water tower, Bergen Dutch Reformed Church, Fort Tompkins 2, Bogart, Summerfield Church	Constable Hook high chimney	0	4	6
Bensonhurst schoolhouse, Owl Head, Schoolhouse 79th street, Elevator, Schoolhouse No. 142, Smith & Gray tower, Prospect water tower, Avenue C schoolhouse	Schoolhouse 60th street, Schoolhouse 41st street, 14th Regiment Armory	10	10	29
St. George schoolhouse, Fort Tompkins 2, Bensonhurst schoolhouse, Schoolhouse 79th street, Schoolhouse 60th street	Inebriate Asylum	0	3	5
Hollis, Seaside Hotel, Prospect water tower, Memorial Church, Castle, Jackson	College Point schoolhouse, Newtown Heights, Payne, Forest Park	14	12	39
Newtown Heights, Forest Park, Lutheran Cemetery Church, Ridgewood Gatehouse, Church Northeast tower, Eppig brewery, 13th Regiment Armory, Pratt Institute, Prospect water tower, Smith & Gray tower, Standish Arms	Schoolhouse No. 143, Covert avenue schoolhouse, Lutheran 2	11	11	31

Straus, Jerome water tower, Parkway, Jackson, Protectory, Ludlow, College Point schoolhouse, Highbridge, Memorial Church	Morris High School	7	7	17
College Point schoolhouse, Payne, Hollis, Forest Park	Normal	3	2	8
Morris High School, Jackson, Memorial Church, College Point schoolhouse, Newtown Heights, Hollis, Normal, Forest Park	Grinnell, North Beach, Steinway School	12	9	30
College Point schoolhouse, Hollis, Grinnell, Normal, Newtown Heights, Lutheran 2, Forest Park	Golf, Hopedale	11	9	26
Steinway schoolhouse, North Beach, Grinnell, Newtown Heights, Lutheran 2, Covert avenue schoolhouse, Eppig brewery, Schoolhouse No. 143	Consumers' brewery	7	6	16
Morris High School, North Beach, Memorial Church, Steinway schoolhouse, Consumers' brewery, Covert avenue schoolhouse, Eppig brewery, Schoolhouse No. 143	Long Island City High School, Sohmer	10	8	24
College Point schoolhouse, Payne, Hollis, Normal, Grinnell, Hopedale, Forest Park, Golf	Flushing High School, Miller	9	7	22
Hollis, Normal, Duck Point, Far Rockaway schoolhouse, Seaside Hotel, Forest Park, Prospect water tower, Canarsie Park, Centennial Tower	Aqueduct schoolhouse	7	7	17
Payne, Hollis, Normal, Golf, Miller, Flushing High School	O'Connell, Weeks	8	6	20
Payne, Hollis, Normal, Forest Park, Aqueduct schoolhouse, Seaside Hotel, Far Rockaway schoolhouse	Jager, Lang, Van Sicklen	12	9	30
Hollis, Prospect water tower, Aqueduct schoolhouse, Jager, Far Rockaway schoolhouse, Seaside Hotel, Ruffle Bar 3, Duck Point, Canarsie Park	Idlewild	8	7	18
Castle, Jackson, College Point schoolhouse, Payne, Hollis, Weeks, O'Connell, Miller, Flushing High School	Bayside, Whitestone schoolhouse	10	9	25
Jackson, Whitestone schoolhouse, Bayside, Weeks, Hollis, Payne	Spinney Church, Taylor	3	7	15
Payne, Hollis, Normal, Lang	Hallock, Belmont	5	3	14
Hollis, Golf, Normal, Van Sicklen, Forest Park, Aqueduct schoolhouse	Richmond High School	5	4	12
Blake Avenue schoolhouse, Church Northeast tower, Ridgewood Gatehouse, Forest Park, Richmond Hill High School, Aqueduct schoolhouse, Duck Point, Canarsie Park	Schoolhouse No. 64, Atkins Avenue schoolhouse, Spring Creek	10	8	27

Old Points Involved.	New Points Determined.	Number Angle Equations.	Number Side Equations.	Number Observed Directions.
Van Sicklen, Jager, Far Rockaway schoolhouse, Idlewild, Ruffle Bar 3, Seaside Hotel	Bayhead Hotel, Enterprise, Arverne Hotel	6	9	23
Payne, Belmont, Hollis, Jager, Far Rockaway schoolhouse	Garden City Cathedral	0	3	5
Payne, Normal, Forest Park, Hollis, Belmont, Lang, Van Sicklen, Jager, Idlewild, Far Rockaway schoolhouse	Metropolitan, Springfield, Roeckle	3	15	25
Idlewild, Jager, Far Rockaway schoolhouse, Enterprise, Arverne Hotel, Seaside Hotel, Ruffle Bar 3, Rockaway Point Life Saving Station	Belle Harbor Church, Edgemere Hotel	3	9	17
Memorial Church, Hollis, Jager, Seaside Hotel, Far Rockaway schoolhouse	Singer Building	0	3	5
Hollis, Seaside Hotel, Jager, Far Rockaway schoolhouse	Metropolitan Life Building	0	2	4
North Beach, Sohmer, Steinway schoolhouse, Consumers' brewery, Long Island City High School	Schoolhouse No. 6	0	3	5
Morris High School, Ludlow, College Point schoolhouse, North Beach, Memorial Church	Riker's Island, North Brother Island lighthouse	2	4	11
Bayside, Whitestone schoolhouse, Castle	Throgs Neck lighthouse (new)	2	1	6
Highwood 2, Memorial Church, Park Row Building, Prospect water tower, Bergen Dutch Reformed Church	Madison Square	0	3	5
Highwood 2, Memorial Church, College Point schoolhouse, Lutheran Cemetery Church, Prospect water tower, Park Row Building, Bergen Dutch Reformed Church	St. Patrick's Cathedral	0	5	7
Bergen Dutch Reformed Church, Ft. Hamilton flagstaff, Centennial Tower, Coney Island lighthouse	Ft. Wadsworth lighthouse	0	2	4

Thoroughness of Adjustment.

The data given above shows great thoroughness in the adjustment of the triangulation and shows the unusually large number of rigid conditions in proportion to the number of observed directions.* Both of these are conducive to a high degree of accuracy in the computed lengths. There are two other exceptional features of the Greater New York triangulation which tend to insure a very high degree of accuracy in the computed lengths.

First, no point in the main scheme of triangulation is more than three figures from the nearest measured base. The connection between the two measured bases is made by a chain of only four figures, including the base nets. The most distant part of the main scheme, in the Borough of Richmond (not between the bases) is only three figures from the edge of the Ocean Parkway Base net. In the primary triangulation of the Coast and Geodetic Survey a connection has seldom been made between bases with less than six figures, including the base nets, and as a rule the number has been much greater than this. Other things being equal, the smaller the number of figures between a given line and the nearest measured base, the greater is the accuracy with which the length of that line is determined.

Second, the points which are not a part of the main scheme in the Greater New York triangulation usually lie within the main scheme and the lines which determine them intersect at angles much more favorable, upon an average, to the attainment of a high degree of accuracy in the determination of lengths than is usually the case. The unusual care taken in the Greater New York triangulation to secure favorable angles of intersection at every point has been one of the important factors in holding the accuracy to a very high standard.

Accuracy of Angle Measurements.

The best available tests of the accuracy of the observations are the corrections to observed directions, the closures of triangles and the discrepancy between measured bases.

The average correction to the 301 observed directions in the main scheme in the Greater New York triangulation is 1″.26, and the average for the 1501 directions in the whole triangulation is 1″.66. In the triangulation by the Coast and Geodetic Survey in 1902 along the 98th meridian the average correction to an observed direction was 0.″27.†

* In the Coast and Geodetic Survey primary triangulation of 1902, along the 98th meridian, the average ratio of the number of condition equations to the number of observed directions was 0.44. In the 99 figure adjustments made in connection with the Greater New York triangulation there is only one in which this ratio is as low as 0.44 and there are several in which it is greater than 0.75.

† See Appendix 4, Coast and Geodetic Survey Report for 1903, "Triangulation southward along the ninety-eighth meridian in 1902." On pages 868, 870-871 of this Appendix the statistics as to accuracy are given for 50 sections of the primary triangulation of the Coast and Geodetic Survey, including that done in 1902 along the 98th meridian. This is the triangulation referred to at several points in the text of this report.

For 49 per cent of the directions in the main scheme the correction is less than 1″.00, and the same is true for 41 per cent. of all the directions in the whole triangulation.

The average closing error of the 168 triangles in the main scheme is 2″.72, and of the 857 triangles in the whole triangulation is 3″.33. In 50 separate sections of primary triangulation by the Coast and Geodetic Survey the average closing error of a triangle varied from 0″.50 to 2″.22.

The length of the Unionport Base as computed from the Ocean Parkway base after satisfying all conditions referring to sides and angles was one part in 25400 greater than the length as measured. Of this discrepancy, which is most conveniently expressed in the computation as 171 in the seventh place of logarithms, 57 in the seventh place of logarithms (1 part in 76000) was distributed in the adjustment between the Unionport base and the line Highbridge-Jackson, 24 in the seventh place (1 part in 180000) between Highbridge-Jackson and Hollis-Memorial Church, and 90 in the seventh place (1 part in 48000) between Hollis-Prospect water tower and the Ocean Parkway base. This distribution was based upon the relative strength of the three sections as fixed by the geometrical conditions involved in the figures.

Accuracy of Lengths.

To compute the probable errors* of the separate lines in the triangulation and thereby secure an estimate of the probability that any particular line is in error by less than 1 part in 25000 would be an extremely difficult and tedious matter. In a triangulation consisting of successive figures with only one line in each figure fixed by preceding computations such a computation and estimate may be easily and quickly made. But in the Greater New York Triangulation as adjusted, each figure contains, as a rule, two or more lines fixed by previous adjustments. This fact that the various figures are connected on many lines, insures an unusually high degree of accuracy in the computed lengths, but as indicated above it also makes the computation of probable errors extremely difficult and long. Hence such computations were not made.

The data given as to the corrections to directions and triangle closures shows that the accuracy of the measurement of the angles in the Greater New York triangulation is considerably below that attained in the primary triangulation of the Coast and Geodetic Survey. This is unavoidable, being due to the difficult conditions peculiar to triangulation in a thickly settled metropolitan district. On the other hand, there are several respects in which this triangulation clearly excels the primary triangulation of the Coast and Geodetic Survey, namely, no line is more than four figures from the nearest base, the various figures are very closely knit together (that is, each new figure starts from two or more fixed lines) the ratio of the number of rigid conditions to the number of directions observed is unusually large, and the angles of inter-

* The expression "probable error" is here used in the technical sense in which it is employed in connection with the method of least squares.

section of the lines fixing each station are unusually favorable to accuracy. It is believed that these excellencies insure, in spite of the unusually large errors in the angle measurements due to city conditions, that the length of every line more than 5000 feet long is known with reasonable certainty within one part in 25000.

In connection with the preceding paragraph it should be borne in mind that it expresses a judgment reached by computers who are experts in this particular line and that this judgment is based upon a study of the computations in detail while in progress and with the 1 in 25000 limit always in mind.

Special Difficulties of Triangulation in a City.

The fact that the conditions of observation in a great city are such as necessarily to reduce the average accuracy of the measurements of angles is well illustrated by the following contrast between observations made with a direction theodolite on special towers in the Greater New York triangulation and the remaining observations in this triangulation made with repeating theodolites mounted, as a rule, on buildings. The average correction to 816 directions observed with repeating theodolites is 1″.87, to 685 directions observed with direction theodolites mounted on special towers is 1″.42, and to 275 directions observed with direction theodolites over lines on which the observations were so made in both directions is only 0″.96.

The contrast between the accuracy attained with the two kinds of theodolites is believed to be due to a minor extent only to the differences between the theodolites. It is believed to be due mainly to the other conditions affecting the accuracy of the measurement of the angles. The direction theodolite was, in every case, mounted on a specially constructed triangular tower and the weight of the observer was supported on another tower entirely independent of and nowhere in contact with the tower supporting the instrument. These special towers furnish a very steady support for the instrument, which is entirely free from any disturbance due to the movement of the observer. The lines over which observations were made from such towers passed in general over the less thickly settled portions of the area covered by the triangulation. On the other hand, although a few of the observations made with repeating theodolites were taken upon such specially constructed towers as were used with the direction theodolites, the great mass of such observations were made with repeating theodolites supported on roofs of buildings. The support of the instrument in such cases was much less steady than that given by the special towers. Unusual care was taken to make the support of the repeating theodolites as independent as possible of the support of the observer. This, however, is an essentially difficult thing to accomplish on the roof of a building and it is to be expected for that reason that angles so measured will be less accurate than those observed from special towers. The disturbance of refraction due to heat from the buildings necessarily introduced another source of error not encountered on the special towers. In certain cases in which chimneys on the building occupied

were emitting much heat it is probable that this introduced unusually large errors into the observations. The observations with the repeating theodolites were made in the more thickly settled portions of the area triangulated and in some cases there were large numbers of chimneys, steam exhaust pipes and smokestacks near the lines of sight which may have introduced irregular refractions in the line of sight and probably, also, reduced the accuracy by making the seeing difficult. At stations on roofs there are frequently special difficulties in measuring the distance and direction from the position occupied by the theodolite to the points observed upon from other stations (a flag staff, for example). This introduces some errors to which the observations at the stations on special towers are not subject.

In general, then, the observations with repeating theodolites were made under the difficult conditions necessarily encountered in making a triangulation in a thickly settled metropolitan district, and the observations with the direction theodolites were made under conditions intermediate between these difficult city conditions and the conditions which are ordinarily encountered in the open country in the primary triangulation of the Coast and Geodetic Survey and which are relatively very favorable to the attainment of a high degree of accuracy.

In comparing the average correction of 1″.42 applied to 685 directions observed with direction theodolites with the average correction of 1″.87 applied to 816 directions observed with repeating theodolites it must be remembered that these are corrections applied in the figure adjustment of the triangulation by least squares. As a rule, the directions observed with a direction theodolite, occurred in figures which also included directions observed with a repeating theodolite. While the purpose of the least square adjustment is to place the corrections where they are needed it is necessarily true that this purpose can be accomplished in part only. Hence, it is reasonably certain that the average correction 1″.42 applied to the directions observed with a direction theodolite is larger than it would have been if these observations had not been associated with the less accurate observations made under more difficult conditions with repeating theodolites. Conversely, the average correction 1″.87 applied to directions observed with a repeating theodolite is probably somewhat smaller than it would have been if these observations had not been closely associated with the more accurate observations made with direction theodolites. An intimate knowledge, gained by the computers by experience, of the manner in which relatively inaccurate observations at one station in a figure treated in an adjustment tends to force larger corrections upon the observations at other stations in that figure than they would otherwise receive, led to the belief that on lines over which observations were made in both directions with direction theodolites the corrections to the observed directions would be less affected by the observations made at surrounding stations with repeating theodolites than are the corrections to the remaining directions observed with direction theodolites on lines over which the observations were made in the opposite direction with a repeating theodolite. The test was made. As already stated it was found that the average correction to the 275 directions observed with direction theodolites over lines on which the

observations were so made in both directions was found to be only 0″.96, but little more than ½ as large as the average correction to all directions observed with repeating theodolites. Even this average correction of only 0″.96 must be somewhat too large to represent truly the accuracy of the observations with direction theodolites for it is necessarily somewhat affected by the observations with repeating theodolites at adjacent stations.

It appears from the above facts that in the adjustment the observations with direction theodolites should have been given greater weight than those made with repeating theodolites. The extent of the contrast between the two classes of observations did not appear until the very close of the computations. Moreover, past experience indicates that the changes which would be made in the final results, especially the lengths, by introducing unequal weights in the place of the present equal weights, would be extremely small, so small as to be of no importance.

Cost of Computation.

The computation of the triangulation of Greater New York furnished the geographic positions of 183 points and the rectangular linear co-ordinates for 178 of these points. The computations made in Washington occupied the equivalent of 5484 hours of the time of one computer. The total cost of these computations was $6039.16. The computations, therefore, required an average of 30 hours for each point determined and the average cost of the computation was $33.00 per point.

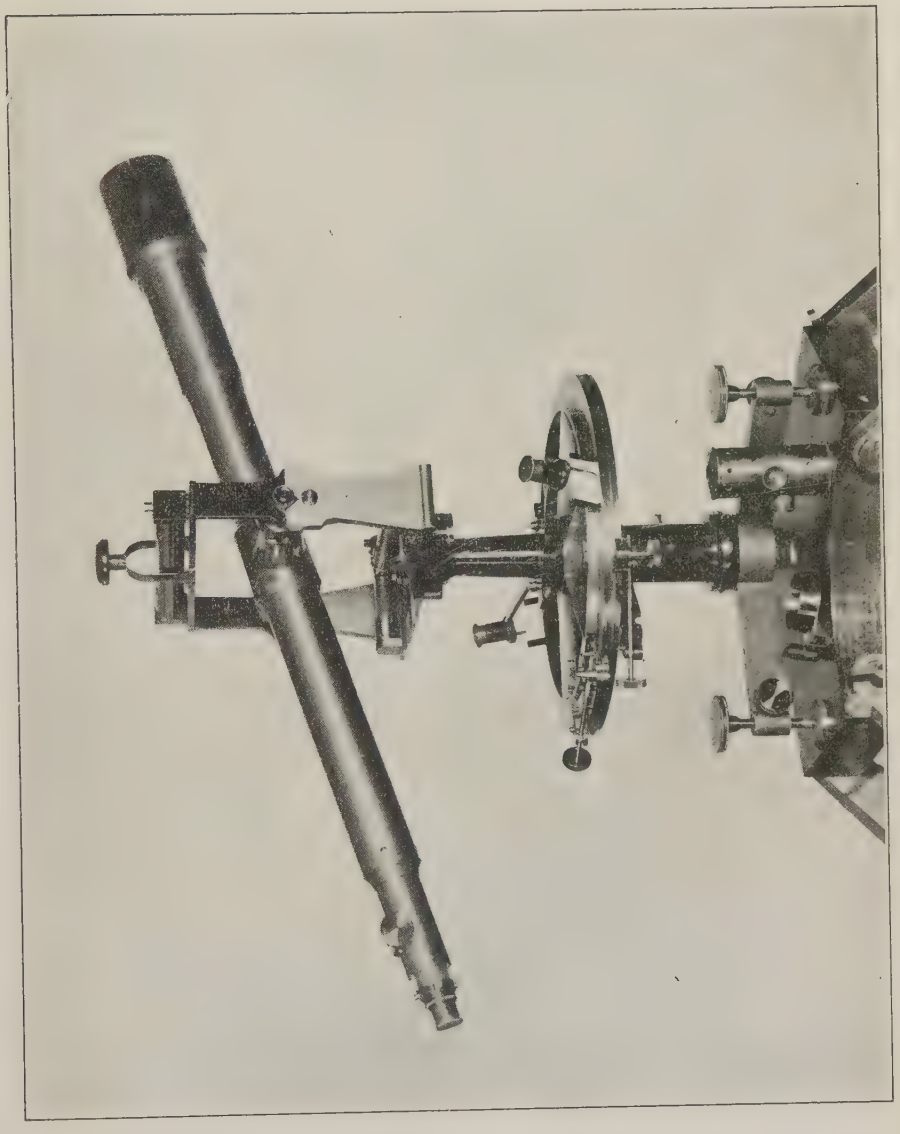

PLATE No. 1—10-INCH GAMBEY REPEATING THEODOLITE No. 63.

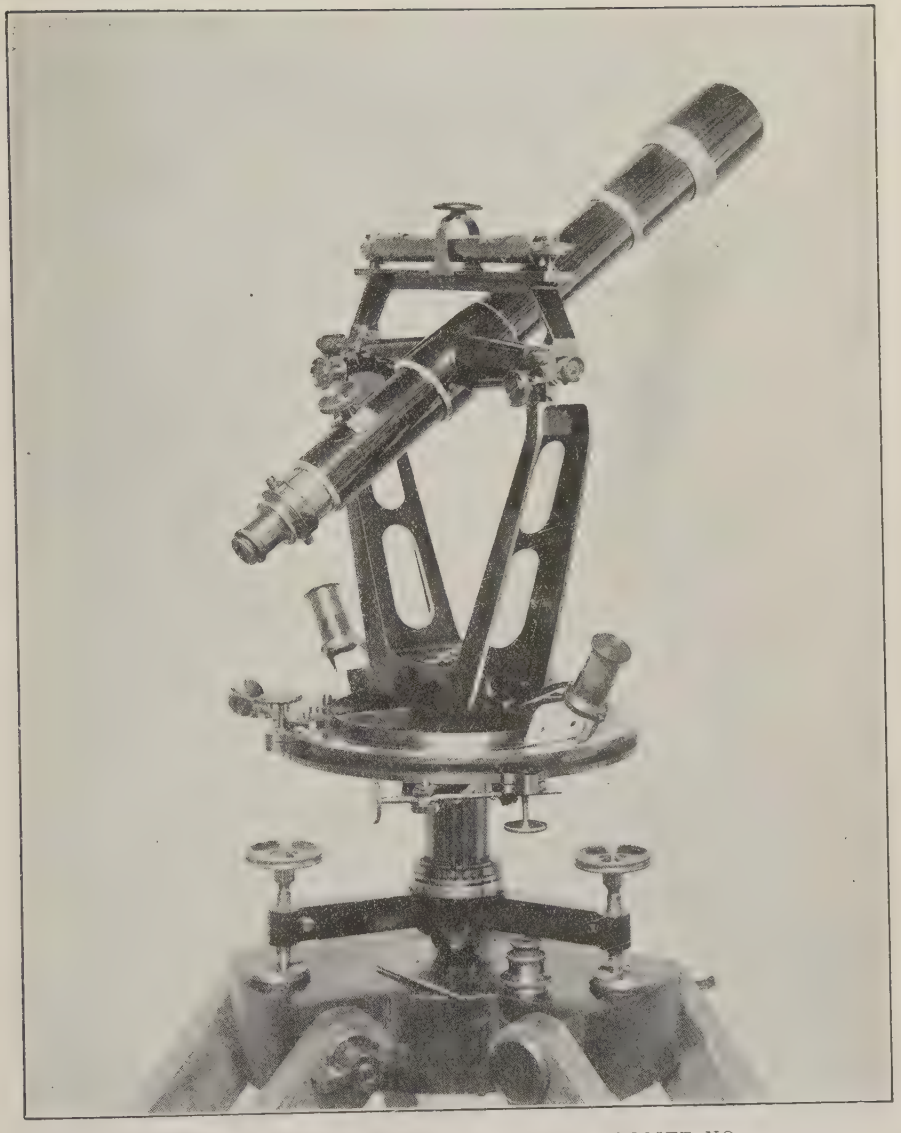

PLATE NO. 2.—6-INCH U. S. C. & G. S. THEODOLITE NO. 29

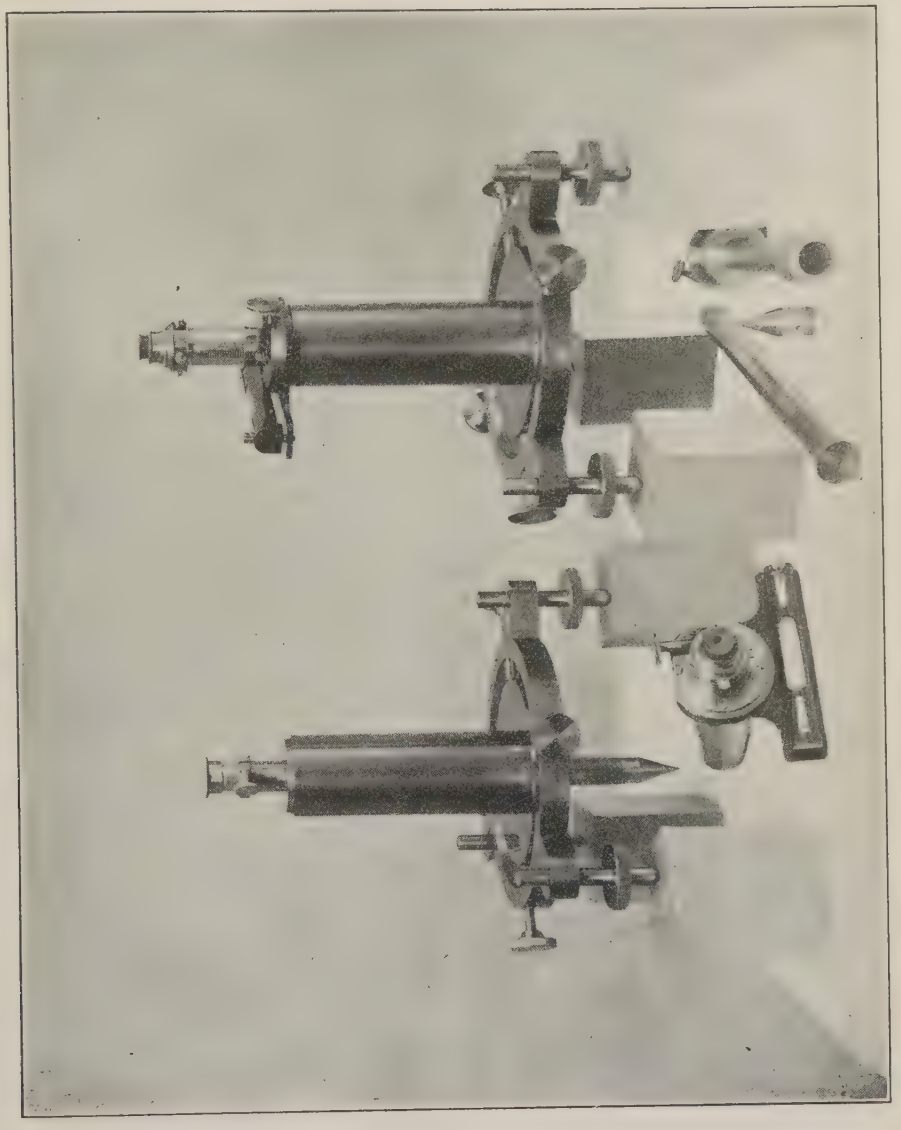

PLATE No. 3—VERTICAL COLLIMATOR U. S. C. & G. S. NO. 2.

PLATE No. 4.—POSITION THEODOLITE U. S. C. & G. S. NO. 168.

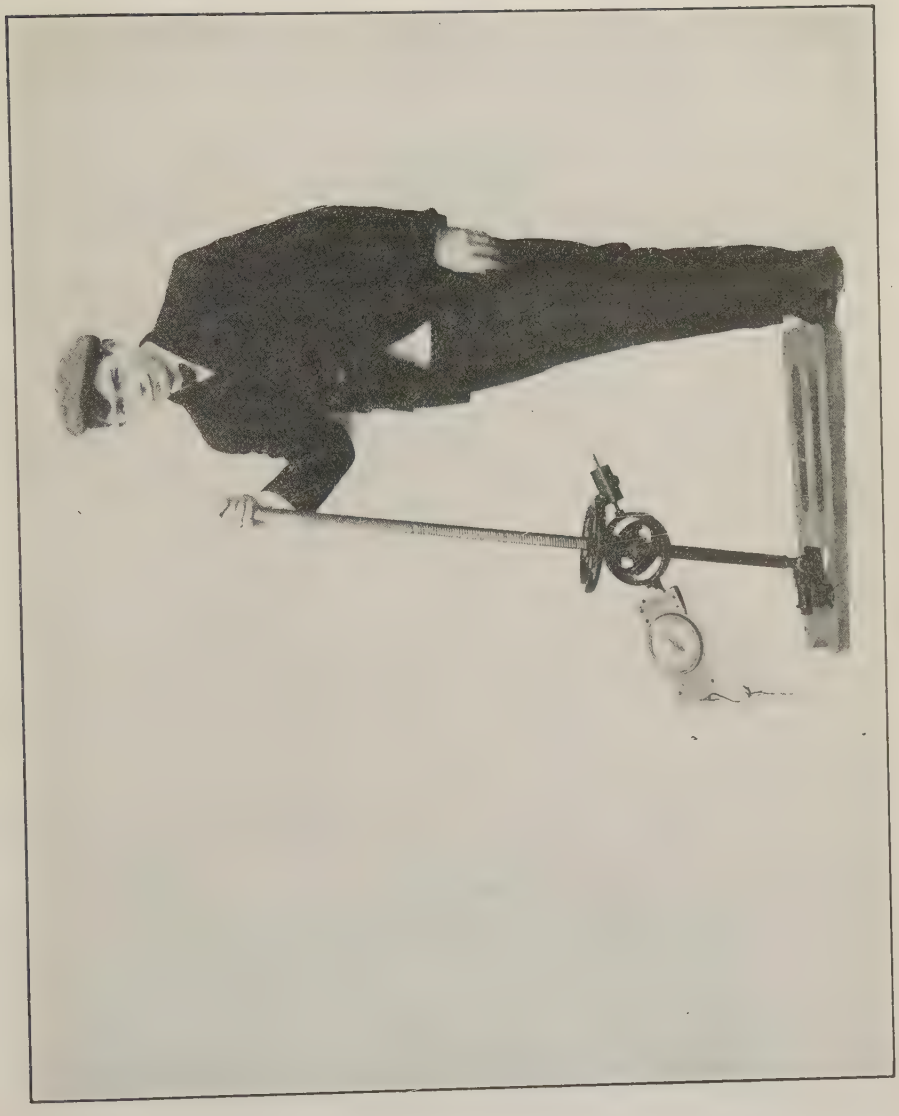

PLATE No. 5—TAPE STRETCHING APPARATUS.

PLATE NO. 6.—SIGNAL AT PROTECTORY—BRONX.

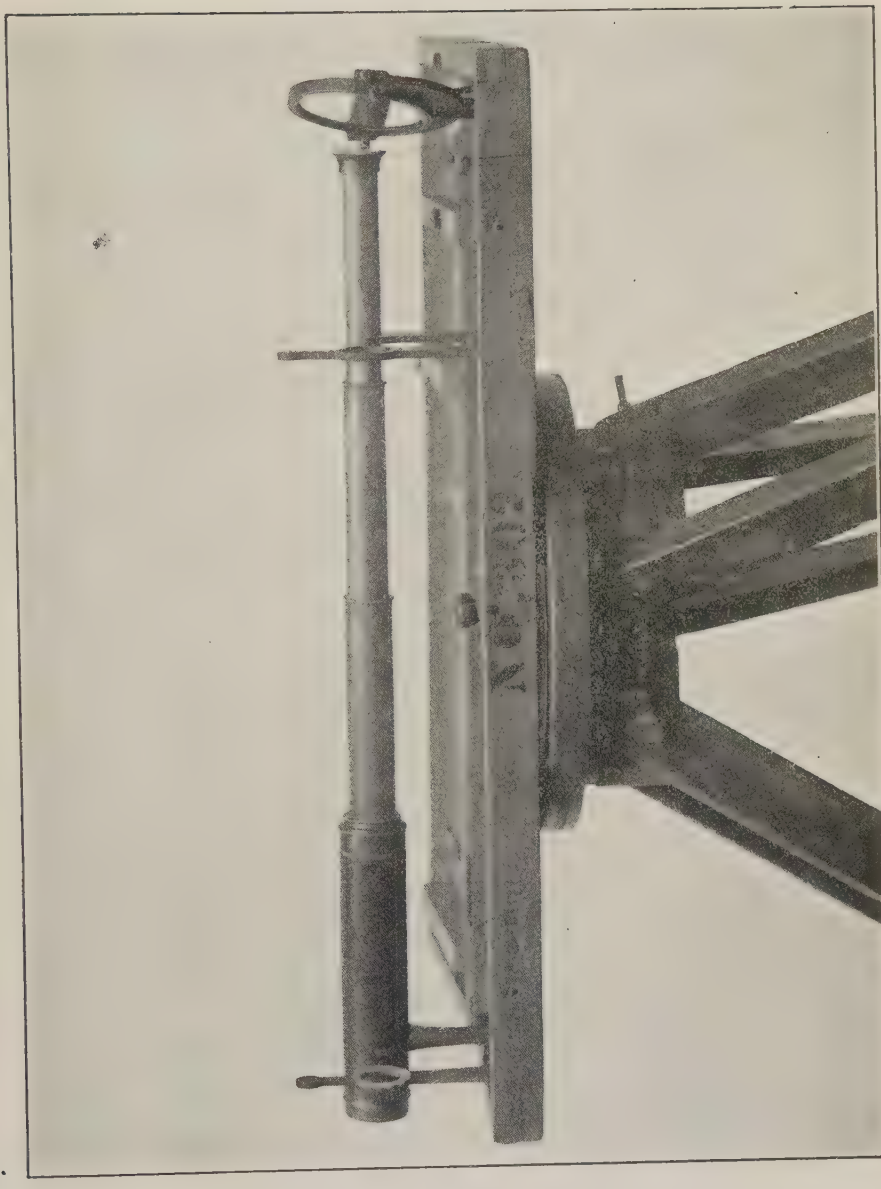

PLATE No. 7.—WOODEN HELIOTROPE.

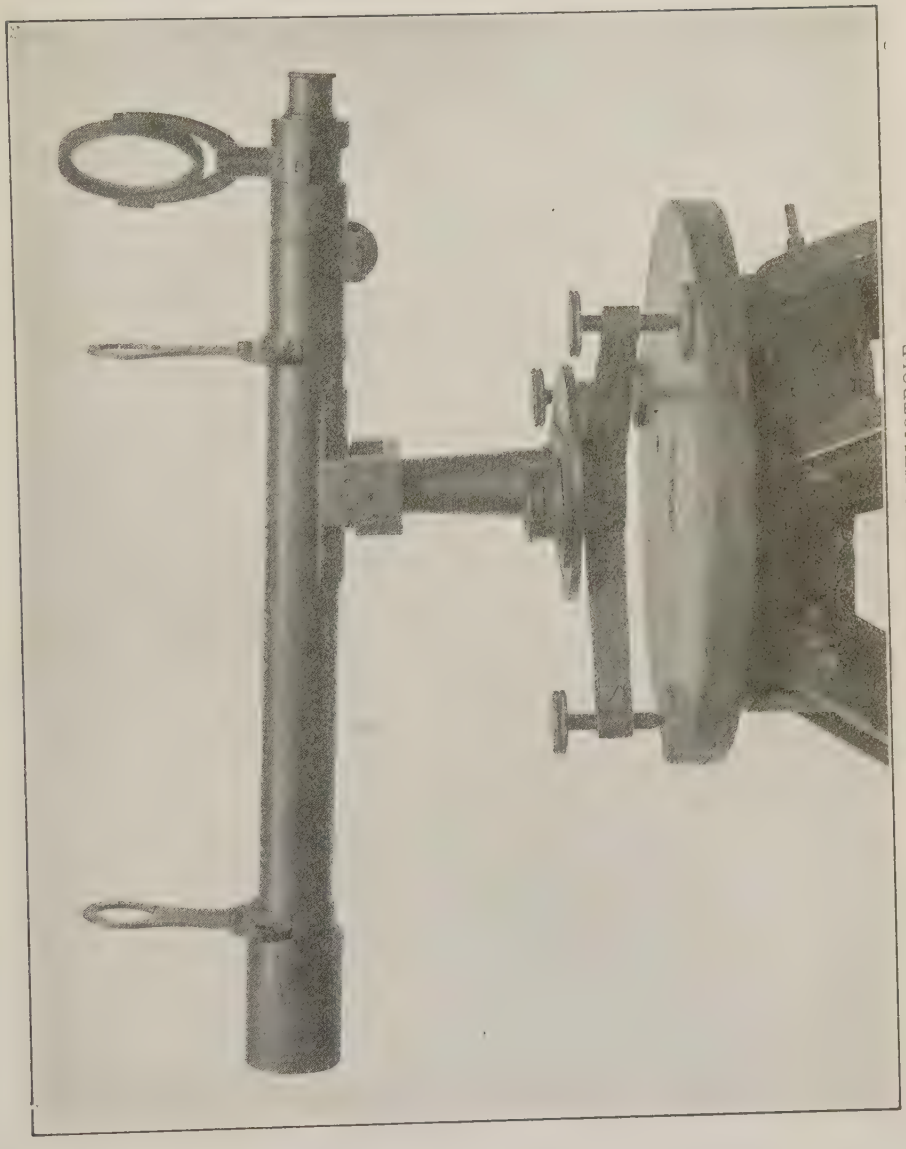

PLATE No. 8.—TELESCOPIC HELIOTROPE.

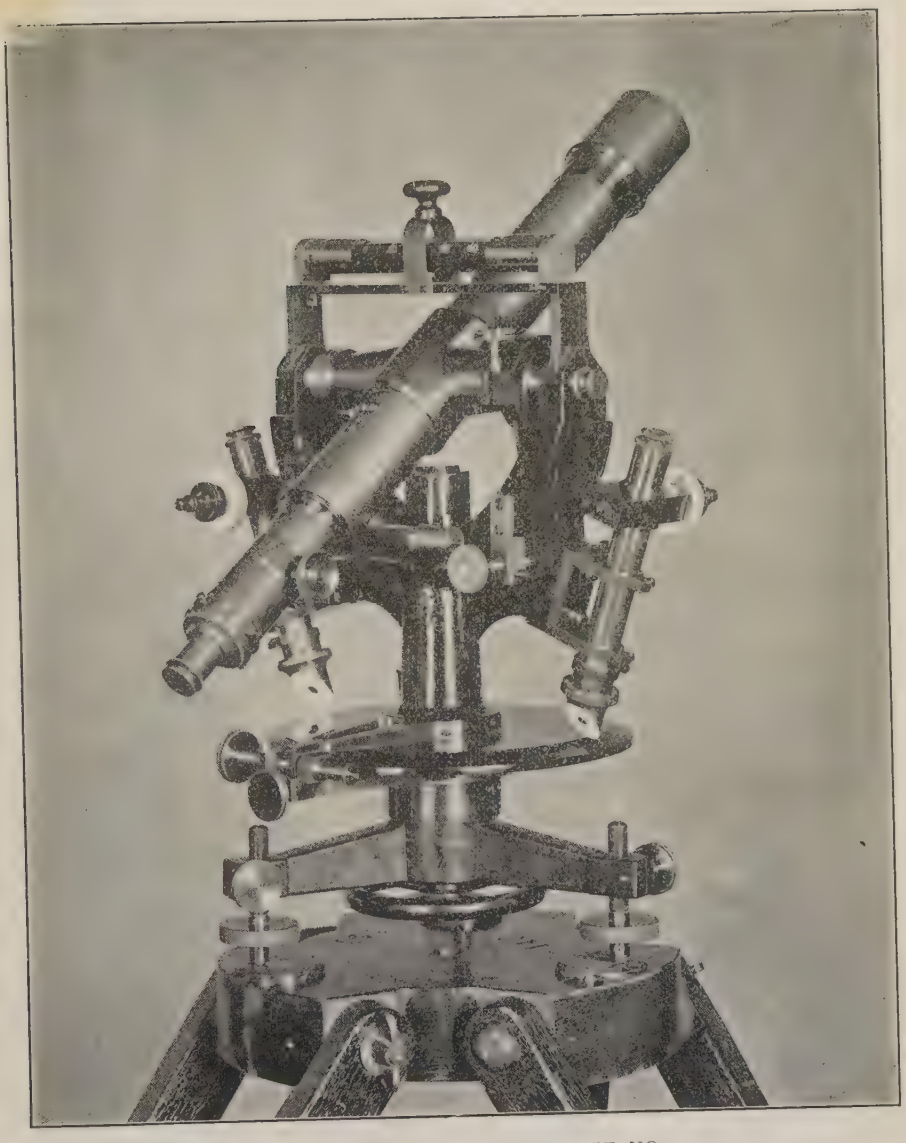

PLATE No. 9—POSITION THEODOLITE NO. 133.

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